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RESULTS OF SEED-TREATMENT EXPERIMENTS WITH YELLOW DENT CORN[1]

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CONTENTS

INTRODUCTION

In connection with the investigations of the corn root, stalk, and ear-rot diseases it early became evident that the germination and general health of corn seedlings in a germination test, particularly in test tubes and Petri dishes, could be improved materially by a treatment of the seed with a suitable disinfectant. These apparently good effects on the seedlings under laboratory conditions, however, were seldom reflected in increased yields in experimental field plots, principally because the injury to the plants from uninfected seed exceeded the beneficial effects on the plants from infected seed. This was true with mercuric chloride and formaldehyde. As a result of these disappointments in experimental field trials, little more attention was given to seed treatment as a means of disease control in dent corn until the introduction of organic mercury compounds for use as seed disinfectants. Organic mercury seed disinfectants were used ex-

[1] These investigations were conducted in cooperation with the Funk Bros. Seed Co., Bloomington, Ill., and the Illinois Agricultural Experiment Station.

[2] Grateful acknowledgment is made to A. G. Johnson for help in preparing the manuscript; to Charles S. Reddy, who was associated with the senior writer during the early part of these investigations; to Boyd C. Frye for assistance in field work and in the tabulation and calculation of data; to J. W. Hardin for assistance in the field experiments; and to W. L. Burlison, of the University of Illinois, for helpful suggestions.

perimentally on corn in Europe several years before they were used on corn in the United States. Charles S. Reddy, then associate pathologist in the Division of Cereal Crops and Diseases, Bureau of Plant Industry, United States Department of Agriculture, in cooperation with the writers of this publication, probably was the first to conduct field experiments whose object was to determine the value of organic mercury compounds as corn-seed disinfectants.

In 1924 Reddy and Holbert (*14*)[3] reported favorable results from the use of chlorophol, an orthochlorophenol mercury compound, as a corn-seed disinfectant on Diplodia-infected seed. Holbert, Reddy, and Koehler (*4, p. 82*) in 1926, summarizing studies extending over a period of five years in Illinois, stated:

> Dent corn grown from seed infected with *Diplodia zeae* and *Gibberella saubinetii* is greatly improved in both yield and quality by seed treatment, while corn from *Fusarium moniliforme* infected and scutellum-rotted seed has not been improved. Only under certain soil conditions, not fully understood, have seed treatments increased the yield of corn grown from seed infected with *Cephalosporium acremonium*. Treated, infected seed has not yielded as well as untreated, nearly disease-free seed.

Reddy, Holbert, and Erwin (*16*), working with sweet corn in Illinois and Iowa from 1922 to 1925, found that seed treatments with organic mercury compounds usually benefited both the stand and yield of sweet corn from seed infected with either Diplodia or Gibberella. Yields from nearly disease-free seed were affected but little by these same treatments. Reddy and Holbert (*15*), in further experiments with seed treatments for sweet-corn diseases, found that dust treatments were more consistent in their beneficial effects than were liquid treatments.

Kiesselbach (*6*) has found that the yields of corn from nearly disease-free seed, from diseased seed, and from farmer-selected seed are neither increased nor decreased significantly by seed treatments with a number of mercuric compounds under conditions existing in Nebraska.

Melhus, Reddy, Raleigh, and Burnett (*11*), working in Iowa and summarizing data from experiments extending over a 5-year period (1923–1927), reported substantial increases in yield from the use of corn-seed treatments on diseased seed and also on various lots of seed taken from farmers' planter boxes.

Holbert, Reddy, and Koehler (*5*) in 1928 reported some of the more practical results from seed-treatment studies conducted in Illinois and Iowa.

Reddy (*12*) found that the acre yield of good seed in the Iowa State field contest was increased about 2 bushels by certain furfural-mercury-dust disinfectants.

It is the purpose of this bulletin (1) to present the results from experiments with several organic mercury compounds and other fungicides for the control of certain diseases of dent corn, (2) to discuss a number of principles involved in the selection of suitable corn-seed disinfectants and the use of these disinfectants in the upper Mississippi Valley, and (3) to state, in the light of the data available, the possible place of corn-seed disinfectants in corn production and in corn improvement.

For a better interpretation of the data presented in this bulletin, there is included a brief discussion of some of the more important diseases of the corn plant traceable primarily to a diseased condition

[3] Italic numbers in parentheses refer to Literature Cited, p. 62.

of the seed and also some of the results from the more recently conducted experiments to determine the influence of different environmental factors in the development of the diseases under consideration. Such knowledge is helpful in appreciating both the limitations and the benefits of corn-seed treatments and in understanding the variations in the effects that follow the use of corn-seed disinfectants.

SEED-BORNE DISEASES AND RELATED MALADIES

DIPLODIA

Diplodia zeae (Schw.) Lev. is generally recognized as one of the most important organisms causing corn ear rot, especially in the more humid portions of the Corn Belt. This fungus also causes a rotting of the stalk and shank tissues. Many apparently good seed ears, as well as the conspicuously rotted ears, may be infected with this fungus.

Seed infection with Diplodia in well-selected seed can be detected by the use of the germination test and sometimes by the outside appearance of the kernels. The appearance of the Diplodia-infected seedlings on the germinator is illustrated in Plate 1.

As the infected kernel germinates, the fungus grows out and attacks the coleorhiza and the mesocotyl. From these it spreads to the seminal and adventitious roots, causing a brown cortical rot, which seldom advances beyond the crown. Many infected seedlings are killed before emergence from the soil, and others succumb to Diplodia seedling blight after emergence. The vigor of plants from Diplodia-infected kernels may be seriously weakened before the crown-root systems are established. Surviving plants from infected seed may or may not produce a normal yield of grain.

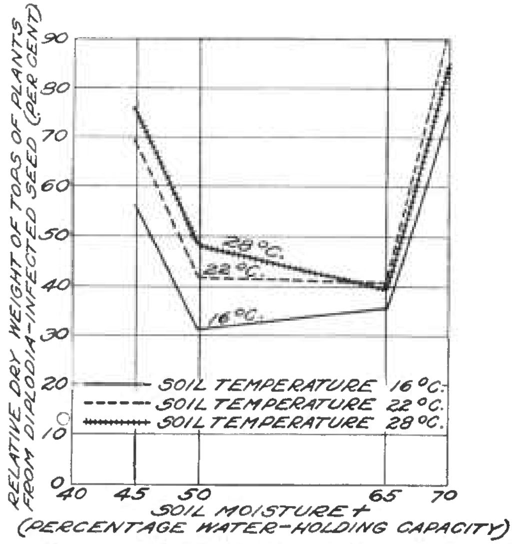


FIGURE 1.—Influence of soil temperature and soil moisture on the growth of corn plants from seed infected with *Diplodia zeae*. (Data, in part, in Table 2)

The extent of the injuries caused by seed-borne Diplodia infection depends largely on soil temperature, soil moisture, and the productivity of the soil. Under low temperature conditions the growth of the corn is relatively slow in comparison with that of the fungus, and a small percentage of the seedlings emerge. (Table 1.) Under warmer soil-temperature conditions a larger percentage of seedlings may emerge, but the proportion of plants blighting after emergence may be greater under the higher soil temperatures. (Table 1.) The growth of plants from Diplodia-infected seed is influenced greatly by soil moisture. (Table 2 and fig. 1.) As compared with the growth of plants from nearly disease-free seed, plants from Diplodia-infected seed made less growth at temperatures of 16°, 22°, and 28° C. with the soil moisture at 50 to 65 per cent of its water-holding capacity than they did with either a lower or a higher soil moisture.

TABLE 1.—*Germination and development of seedling blight in three varieties of yellow dent corn grown from Diplodia-infected seed untreated and treated with Uspulun*[1] *(1½-hours soak in 0.25 per cent solution at 30° C.), as influenced by five different temperatures, University of Illinois, 1925*[2]

Temperature	Germination of—		Difference in percentage germination		Blighted plants from seed	
	Untreated seed	Treated seed	Increase	Decrease	Untreated	Treated
° C.	*Per cent*	*Per cent*			*Per cent*	*Per cent*
10	36.0	73.3	37.3		1.4	0
15	44.0	89.0	45.0		26.1	2.8
20	50.8	80.5	29.7		30.7	11.1
25	79.2	77.6		1.6	62.1	.2
30	80.8	87.6	6.8		62.1	0

[1] A compound manufactured in Germany, the active principle of which is hydroxymercurichlorophenol.
[2] Data from experiments conducted in the controlled-temperature chambers devised by Charles F. Hottes, plant physiologist, department of botany, University of Illinois.

TABLE 2.—*Influence of soil temperature and soil moisture on relative dry weights of tops of three varieties of yellow dent corn plants grown from Diplodia-infected seed as compared in percentage with those of tops of corresponding plants grown from good seed of the same varieties taken as 100 per cent, University of Illinois, 1925*[1]

Moisture content and temperature of soil	Dry weight of tops	Moisture content and temperature of soil	Dry weight of tops
45 per cent moisture:	*Per cent*	50 per cent moisture:	*Per cent*
16° C.	56.6	16° C.	31.9
22° C.	69.8	22° C.	42.9
28° C.	75.8	28° C.	48.7
Mean	67.4	Mean	41.2

[1] Data from experiments conducted in the controlled-temperature tanks in the agronomy greenhouses.

Although later plantings of Diplodia-infected seed have resulted in better stands and higher yields, later plantings of good seed have consistently yielded at a lower rate than have the earlier plantings. (Table 3.)

TABLE 3.—*Field stands and acre yields of several strains of yellow dent corn from good seed and from Diplodia-infected seed planted on three dates; averages of 22 experiments*[1] *conducted in five different years in central Illinois, 1921–1925*

Time of planting	Field stand from untreated—		Acre yield from untreated—	
	Good seed	Diplodia-infected seed	Good seed	Diplodia-infected seed
	Per cent	*Per cent*	*Bushels*	*Bushels*
First week in May	90.0	34.3	80.7	33.0
Middle of May	94.0	50.4	78.3	43.7
Last week in May	94.1	70.6	70.6	50.7

[1] Each of these experiments was conducted on uniform soil. The rows were 175 feet long and replicated 8 to 12 times.

Diplodia ear rot and Diplodia stalk rot both are caused by wind-borne spores. The fungus may gain entrance into the ear through the silk, through a break or injury of the shank, or by being carried down in between the corn husks by moisture and there entering the shank directly. The ear is susceptible to attack from the silking period to maturity and thereafter until it has dried down to approximately 22 per cent moisture. Early ear infection results in badly rotted ears, while very late infections often can not be detected by external appearance. Warm, moist weather is most favorable for ear infection by Diplodia.

The Diplodia disease of corn has been reported from widely scattered sections in this country and from several foreign countries. In the United States the greatest damage from this disease probably occurs in the more humid sections of the upper Mississippi Valley Corn Belt, extending from the central part of Ohio on the east to western Iowa on the west.

The losses from Diplodia ear rot and the extent of Diplodia ear infection vary greatly from season to season, depending on climatic conditions. Diplodia infections usually are higher where corn follows corn than where corn follows some other crop.

Varieties and strains differ greatly in resistance and susceptibility to this disease (*3*). Some widely grown commercial varieties of recognized merit are comparatively susceptible to Diplodia ear rot Strains have been developed, however, which are remarkably free from both Diplodia and Gibberella ear rots under widely different conditions and at the same time have the capacity for producing high yields.

The absence of ears badly rotted by Diplodia and by Gibberella is no assurance of freedom from slight infections in seed selected from the same sources. Seed of strains of corn considered highly resistant to Diplodia and Gibberella ear rots may contain a relatively high percentage of seed infection with these two fungi. Strain A in Table 4 was practically free from ears visibly rotted by Diplodia in the field. Seed of strain A selected from this same field, however, carried 9.3 per cent Diplodia seed infection. Again, seed of strain B, which might be considered almost immune from Gibberella ear rot, carried 12.5 per cent Gibberella seed infection.

TABLE 4.—*Diplodia and Gibberella ear rots and seed infection in yellow dent corn from the same fields, using two strains of yellow dent corn, Bloomington, Ill., 1927 and 1928*

Strain of corn	Ears rotted in the field by—		Seed selected from the same field slightly infected with—	
	Diplodia	Gibberella	Diplodia	Gibberella
	Per cent	*Per cent*	*Per cent*	*Per cent*
A	0.6	0	9.3	0.1
B	1.9	0	.1	12.5

The extent of seed infection in commercial seed lots and farmers' seed lots varies greatly with different varieties, in different sections, and from season to season. While some lots of seed may be practically free from infection with this fungus, other lots may contain from 15 to 30 per cent infection, or even more.

GIBBERELLA

Gibberella saubinetii (Mont.) Sacc., in addition to causing head and seedling blight of wheat, barley, and oats, is, like *Diplodia zeae*, an important corn ear-rot fungus. And, as with Diplodia, many apparently good ears may carry slight infections with Gibberella that may be detected only by the use of a germination test. (Pl. 1.)

On the germinator the infected seedlings present a drier and darker brown rotting of the mesocotyls than do Diplodia-infected seedlings. The mycelial growth of *G. saubinetii* on the seedlings has a tinge of color shading from white or yellow to a delicate pink or deep red, whereas the mycelial growth of *D. zeae* is always white, surrounding the infected parts of the seedling in thick, cottony tufts. Kernels on the germinator, dead as a result of Gibberella invasion, are pinkish or red in color. Kernels killed by Diplodia acquire a dull shade approaching black in color.

Experience has shown that sometimes much slight Gibberella seed infection fails to become evident in the ordinary germination test made at a temperature of 75° F. or over. Yet when seed slightly infected with Gibberella is planted in cool soil, as usually occurs at the proper time for corn planting, much injury may result. In such cases seed treatments may be especially valuable as a supplement to the germination test.

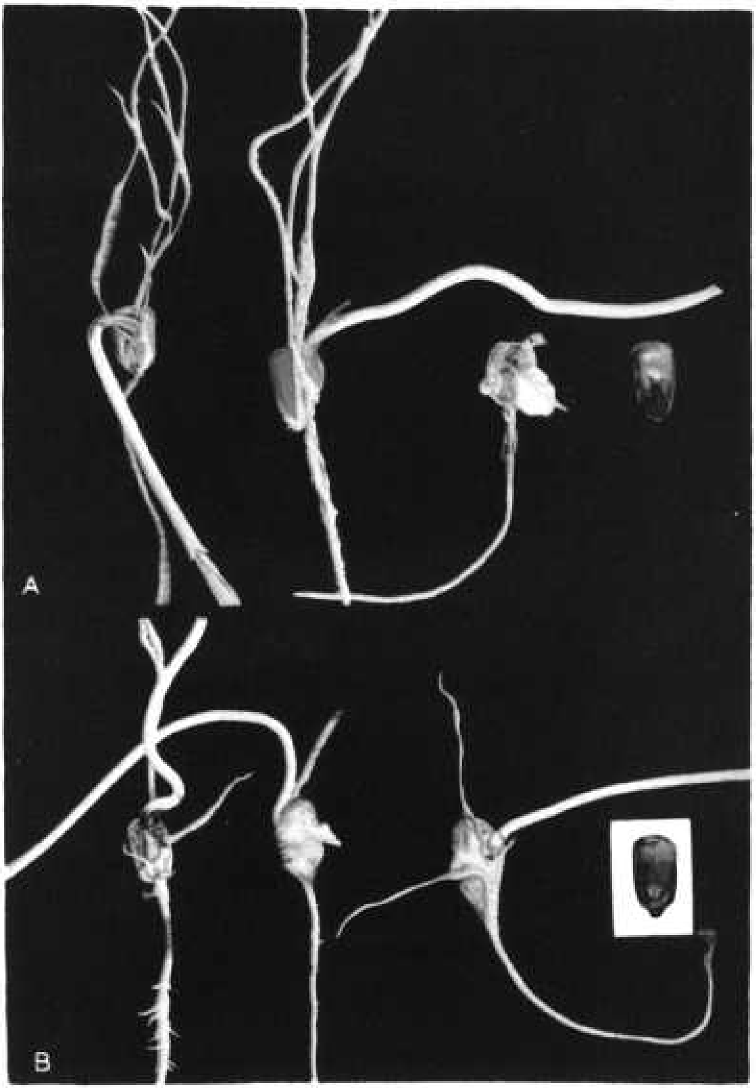
Gibberella infection can be detected less readily than Diplodia infection by a physical examination of the ear and kernels. In fact, sometimes there may be a higher percentage of Gibberella infection in well-selected but untested lots of seed than in the same lots prior to the elimination of undesirable ears on the basis of ear and kernel characters. (Table 5.) Gibberella-infected ears and also Diplodia-infected ears that are found in the better seed lots usually are well matured and have an inherent capacity for producing high yields when the disease is controlled.

TABLE 5.—*Gibberella seed infection in discarded and selected ears in a 200-bushel lot of rack-dried seed corn, Bloomington, Ill., 1927*

Kind of seed	Percentage of original seed lot	Percentage of Gibberella-infected kernels
Discarded from the seed stock on the basis of undesirable ear and kernel characters	10.5	0.2
Selected as good seed on the basis of a careful inspection of ear and kernel characters	14.6	7.6

The cortical rots caused by Gibberella, like those caused by Diplodia, are confined chiefly to the coleorhiza, the mesocotyl, and the seminal and adventitious roots. The use of Gibberella-infected seed may result in very unsatisfactory stands and much seedling blight.

The extent of reduced stands, seedling blight, and weakened early vigor resulting from the use of Gibberella-infected seed depends on soil and climatic conditions and the genetic complex of the strain of corn. Plantings of Gibberella-infected seed followed by a period of



RESULTS OF SEED-TREATMENT EXPERIMENTS FOR DENT CORN

Germinating kernels infected with (A) *Diplodia zeae*, (B) *Gibberella saubinetii.*

cold weather may produce very unsatisfactory stands or a marked reduction in early vigor. But corn from Gibberella-infected seed is not adversely affected by a combination of high soil temperature and high soil moisture, as is corn from Diplodia-infected seed. At soil temperatures above 66° F. there is but little seedling blight caused by *Gibberella saubinetii.*

While a moderately high soil-moisture content, 50 to 65 per cent of the water-holding capacity, favors the maximum development of Diplodia seedling blight, Gibberella seedling blight is favored by lower moisture contents.

Gibberella ear rots and stalk rots, like those caused by Diplodia, do not result from a systemic infection of the plant, but from wind-borne spores. With Diplodia ear rot usually about as many ears are infected from the shank end as are infected from the tip end. However, the tip-infected ears are decidedly in the majority with Gibberella-rotted ears. Ears are susceptible to infection from silking to maturity, as is the case with Diplodia.

The occurrence of cereal head blight or scab throughout the Corn Belt is evidence of the wide distribution of *Gibberella saubinetii.* Although rather heavy infections of seed corn with *G. saubinetti* have been reported from various States, ordinarily it probably is not as generally prevalent in seed corn as is *Diplodia zeae.* The relative proportions of these two seedling-blight fungi in seed corn depend on a number of factors, chief among which are climatic conditions, previous cropping, and the genetic complex of the corn involved. For instance, in the 1924 crop throughout central Illinois there was about an equal amount of Diplodia and Gibberella infection, while in the 1925 crop there was an abundance of the former and only traces of the latter in commercial strains throughout the same area. Many inbred strains and recombinations of inbreds in the 1925 crop, however, contained high percentages of the Gibberella, with only traces of Diplodia.

In general, it may be stated that Gibberella ear rot and Gibberella seed infection are more prevalent in the northern parts of the upper Mississippi Valley Corn Belt than in the central and southern parts. There is much seasonal and varietal variation in the occurrence and amount of Gibberella infection.

BASISPORIUM

Basisporium gallarum Moll., like *Diplodia zeae* and *Gibberella saubinetii,* may cause a rotting of the stalk, shank, and cob tissues. The butts of ears from Basisporium-infected shanks present a shredded appearance. Cobs rotted by Basisporium are easily broken, and cobs of ears badly rotted by this fungus may easily be crushed in the hand or split longitudinally.

The fungus infects the kernels and in severe cases kills them. In the kernel the attack of the fungus is primarily on the embryo, not on the endosperm. Infected ears usually are light in weight, dull in luster, and chaffy. In late infections, however, the kernels are not killed, and infected ears may have a good appearance. Such ears may be, and frequently are, selected for seed. Many lots of seed from farmers' planter boxes that were free from both Diplodia and Gibberella infections have been found to contain from 15 to 30 per cent Basisporium-infected seed.

Heavy Basisporium infection in seed ears can best be detected by a careful examination of the butt of the ear. Infected ears, as a rule, do not have clean, bright shank attachments. A tip of an infected kernel is shown in Figure 2. The black spots in these pictures are not single spores but are groups or masses of spores. Slight infection may easily escape detection by the unaided eye.

On the germinator Basisporium infection of seed is not so easily recognized as are Diplodia and Gibberella infections. The fungus is inconspicuous, and there is little evidence of rotting. The mycelium is white and fluffy but sparse. Identification must be made with the aid of a microscope. An enlarged photograph of infected kernels

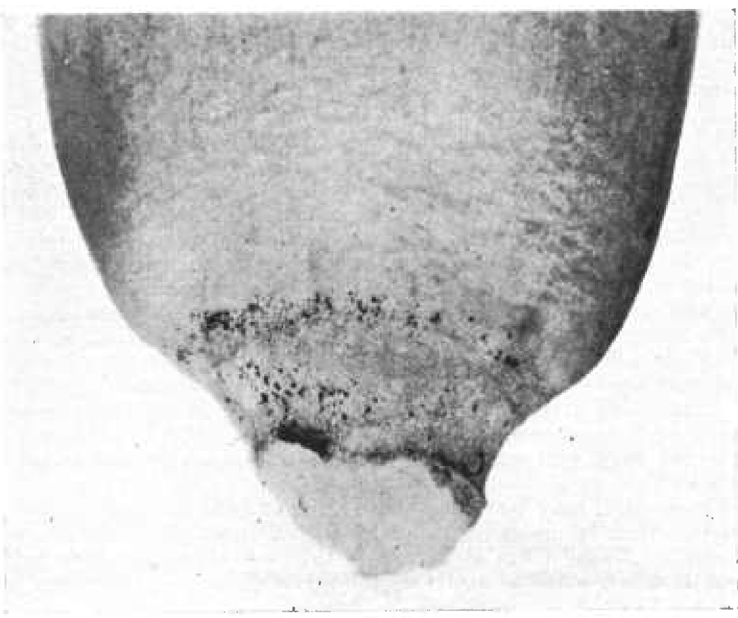


FIGURE 2.—Tip of corn kernel (× 15) showing Basisporium spore masses, which are scarcely noticeable to the naked eye. Basisporium infections of this kind frequently are found in seed corn

from a germinator is reproduced in Figure 3. The moisture on the germinator makes the spores a little more conspicuous than they are on the dry grain, but otherwise they can be recognized just as readily on the dry grain. On the germinator the seedlings from ears slightly infected with Basisporium are more slender and less vigorous than the seedlings from ears slightly infected with either Diplodia or Gibberella, especially the latter.

Varieties and strains of corn differ greatly in their resistance and susceptibility to Basisporium. There also is much seasonal variation in the occurrence and severity of this disease.

Not all Basisporium-infected ears show the external symptoms described above. The presence of slight Basisporium infection in many ears can be determined only by surface disinfection, plating, and subsequent identification of the fungus.

The use of Basisporium-infected seed is followed by a reduction in stand, vigor, and yield. In the experiment the results from which are given in Table 6 the Basisporium-infected seed, as well as the nearly disease-free seed, was selected from a 10-year inbred which had been pollinated by another and unrelated 10-year inbred. On the limestone-sawdust germinator the seedlings from the Basisporium-infected ears appeared as vigorous as the seedlings from the nearly disease-free ears. The nearly disease-free seed composite of the same first-generation cross had a vitality of 99.8 per cent, with 92.4 per cent of the seedlings apparently disease-free, on the germinator. The Basisporium-infected seed selected had a vitality of 99.5 per cent, with 95 per cent of the seed slightly infected. Otherwise the seedlings from this Basisporium-infected seed appeared as desirable as the seedlings from the nearly disease-free seed. In the field the nearly disease-

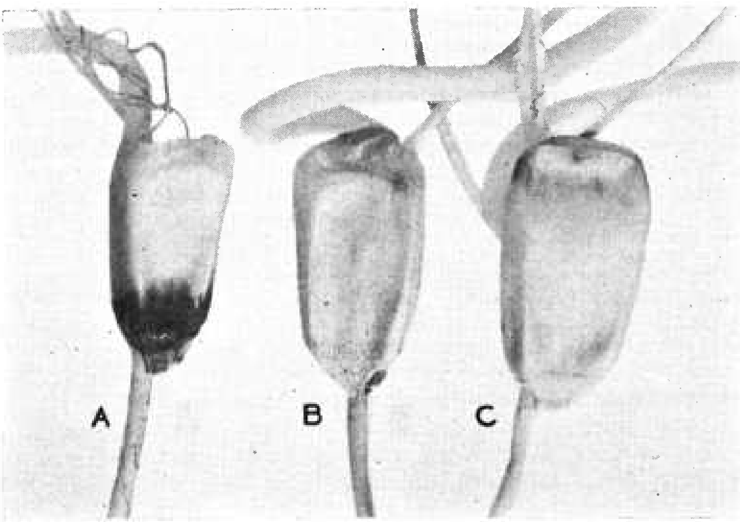


FIGURE 3.—Germinating kernels at the time of reading the germination test: A, Badly infected with Basisporium; B, slightly infected with Basisporium; C, apparently disease free

free seed gave a final stand of 85.6 per cent and the Basisporium-infected seed a stand of 79.6 per cent. The reduction in acre yield of 4.8 bushels was statistically significant, the odds being 160 to 1. The use of seed more heavily infected with this fungus has resulted in greater reductions in yield, the reductions ranging from 5 to 15 bushels per acre.

TABLE 6.—*Field stand*[1] *and acre yield*[1] *of yellow dent corn from nearly disease-free seed and from Basisporium-infected seed, each composite selected from seed of a first-generation cross between two 10-year inbreds of yellow dent corn, planted early in May, 1927, near Bloomington, Ill.*

Kind of seed	Vitality (laboratory record)	Final field stand	Acre yield	Decrease in yield following use of Basisporium-infected seed	
	Per cent	*Per cent*	*Bushels*	*Bushels*	*Odds*
Nearly disease-free	99.8	85.6	58.7		
Basisporium-infected	99.5	79.6	53.9	4.8	160:1

[1] Average of 21 replications.

The factors determining the extent of injury caused by seed-borne Basisporium infection are not fully understood. In general, however, earlier plantings of Basisporium-infected seed followed by unfavorable weather conditions, such as cold rains, etc., have resulted in greater reductions in stand and yield than have later plantings followed by more favorable weather conditions. (Table 7.) Also, reductions in the acre yields of corn from Basisporium-infected seed, as compared with the acre yields of corn from nearly disease-free seed, have been greater on the more productive than on the less productive soils. (Table 8.) It is not known whether this is due to the increased injury from the disease on the more productive soil or to the inferior capacity of corn susceptible to Basisporium to utilize efficiently the larger supply of plant nutrients present in the more productive soil. In view of the fact that the yield of corn from Basisporium-infected seed as shown on p. 53 was increased only 2.5 bushels by seed treatment, as compared with increases of 15.1 and 9.8 bushels from treated Diplodia-infected and Gibberella-infected seed, it would seem that the latter suggestion has some basis. On moderately productive soil, individual plant yields of corn from treated Basisporium-infected seed are significantly lower than plant yields of corn from either treated Diplodia-infected or treated Gibberella-infected seed. (Table 9.)

Table 7.—*Reductions in acre yield* [1] *of yellow dent corn from seed heavily infected with Basisporium as compared with the yield from nearly disease-free seed, the first of the two plantings being followed by a period of unfavorable weather and the second by a period of favorable weather at Bloomington, Ill., 1927*

Time of planting	Reduction in yield following use of Basisporium-infected seed	Odds
	Bushels	
Early in May and followed by a period of unfavorable weather conditions	13.0	>9,999:1
Middle of May followed by favorable weather conditions	7.4	>9,999:1

[1] Averages of 15 replications.

Table 8.—*Acre yields from good seed and from Basisporium-infected seed corn grown on soils of different levels of productivity, at the University of Illinois agronomy farm, Urbana, Ill., 1927 and 1928*

Year	Replications	Acre yield from— Good seed	Acre yield from— Basisporium-infected seed	Increase (+) or decrease (−) in yield from use of Basisporium-infected seed	Odds
	Number	*Bushels*	*Bushels*	*Bushels*	
1927	10	63.2	52.6	−10.6	2,099:1
	9	56.6	51.9	−4.7	73:1
	5	52.1	51.6	−.5	3:1
1928	8	66.3	59.3	−7.0	>9,999:1
	16	53.6	50.5	−3.1	38:1
	8	32.9	35.4	+2.5	8:1

TABLE 9.—*Plant yields of yellow dent corn, in experimental plots with comparable field stands, grown from Diplodia-infected seed, from Gibberella-infected seed, and from Basisporium-infected seed (all seed lots treated), Bloomington, Ill., 1927–1929*

Kind of seed	Mean plant yield [1]— 1927	1928	1929	Average
	Pounds	*Pounds*	*Pounds*	*Pounds*
Diplodia-infected	0.778	0.791	0.927	0.832
Gibberella-infected	.758	.836	.883	.826
Basisporium-infected	.637	.734	.875	.749

[1] Each average is based on the yield from approximately 700 comparable plants.

Basisporium ear rots and seed infection with Basisporium apparently are widely distributed throughout the upper Mississippi Valley Corn Belt. In 1928 Basisporium ear rot was decidedly more prevalent than either Diplodia or Gibberella ear rot throughout central Illinois. Durrell (*1*) pointed out that the earlier maturing varieties were more heavily infected than the later maturing ones. He also stated that this disease was more prevalent in seasons in which there was a heavy rainfall during the fall months. It has been the observation of the writers that following premature killing of the plants by cold or by other agencies there is a rapid invasion of the stalk, shank, and cob by Basisporium and by other organisms.

The presence of Basisporium infections in seed corn in many instances may be evidence of physiologic immaturity of the seed and also evidence of the inability of the plants from which such seed was selected to bring their maturation processes to completion under unfavorable weather and soil conditions.

FUSARIUM

In some sections of the Corn Belt, *Fusarium moniliforme* Sheldon is an important ear-rot producing organism. Good-appearing seed lots of which 50 per cent of the kernels carry Fusarium infection are not unusual.

The infection is carried in the tip cap of the kernel, and, as shown in Plate 2, a pink mycelial growth develops in this region on infected kernels during the germination test. In habit the fungus is not spreading, but grows close to the kernel, and at times a microscopic examination is necessary to distinguish Fusarium infection from Cephalosporium infection. (Fig. 4.) When the corn is susceptible to scutellum rot or when the germinator is not sufficiently ventilated, Fusarium infection may be masked by other more vigorously growing fungi, such as Rhizopus. Sometimes red streaks occur on the seed coat of infected kernels. No conspicuous rotting of the seedlings on the germinator is caused by this fungus, but a rot at the base of the seminal roots sometimes may occur.

No outstanding field symptoms are associated with plants grown from seed infected with *Fusarium moniliforme*, and some investigators have questioned whether seed infection with this fungus has any practical significance. In experiments conducted in Illinois, slight reductions in stand and vigor usually have followed the use of Fusarium-infected seed, and reductions in yield have been the rule. On soils lacking lime and phosphorus, reductions in yield of sound corn from Fusarium-infected seed have been pronounced. Corn

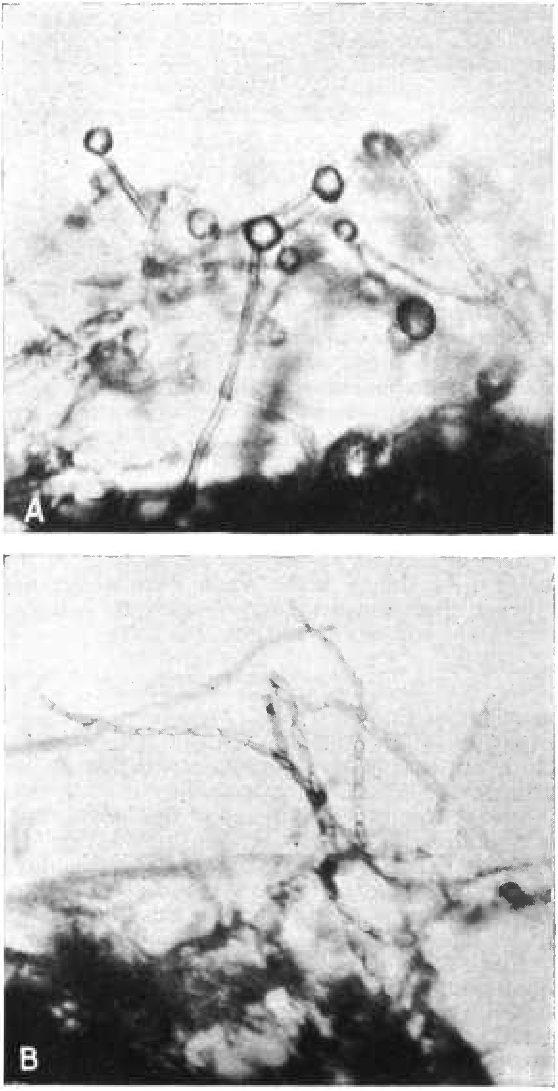


FIGURE 4.—A.—*Cephalosporium acremonium* fruiting at the tip end of an infected corn kernel taken from the germinator. The round spore heads here shown are characteristic. B.—*Fusarium moniliforme* photographed at the same magnification as A. The spores are produced in chains rather than in heads, as in Cephalosporium. ×650

from seed infected with this organism frequently has been very susceptible to injury from unfavorable environmental conditions.

Fusarium moniliforme, used in pure-culture seed-inoculation studies in extensive field experimental plots, has never given any consistent reduction in stand, vigor, or yield. These inoculation studies were conducted in cooperation with James G. Dickson, of the Division of Cereal Crops and Diseases, and the University of Wisconsin. Apparently many physiologic strains of this organism may exist, according to results recently reported by Leonian (*10*). Some of these strains probably cause injury to corn seedlings when infections with such strains are seed borne. Seed treatment has possibilities of increasing the yield of corn from Fusarium-infected seed, at least to the extent of controlling these injurious infections.

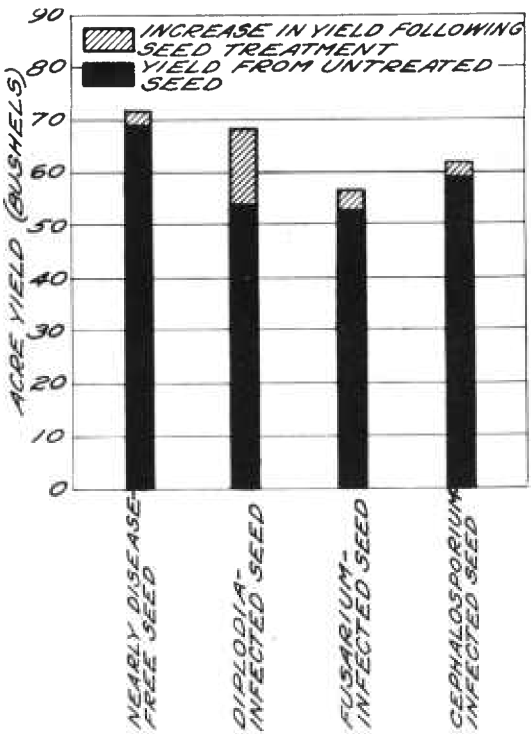


FIGURE 5.—Acre yields from nearly disease-free, Diplodia-infected, Fusarium-infected, and Cephalosporium-infected seed, untreated and treated. (Data in Table 10)

The degree to which individual ears may be infected with *Fusarium* spp., as well as the severity of the infections, depends largely on the genetic complex of the corn involved. Slightly infected ears of a strain resistant to this organism usually give a yield closely approaching that of corn from nearly disease-free ears of the same strain. On the other hand, heavily infected ears of Fusarium-susceptible strains may produce corn of low-yielding capacity as compared with corn from nearly disease-free ears selected from the same open-pollinated strain. Data from an experiment in which such a comparison was made are presented in Table 10. Corn from seed heavily infected with Fusarium yielded little better than corn from Diplodia-infected seed, and each produced a yield significantly below that of corn from the well-selected, nearly disease-free seed from the same seed lot. It is possible that this nearly disease-free seed was disease free because the plants producing the seed were highly resistant to both Fusarium and Cephalosporium. Corn from Fusarium-infected seed was benefited only slightly by seed treatment, 3.2 bushels with odds of 4 to 1, and corn from treated Diplodia-infected seed gave a yield increase of 13.3 bushels with odds of 4,132 to 1. A summary of these results is shown graphically in Figure 5. The ears produced by the corn grown from Fusarium-infected seed were inferior in quality, and many were rotted. Ears heavily infected with Fusarium usually are more starchy in endosperm composition than are nearly disease-free ears from the same seed lot, although many heavily infected ears have a good external appearance.

TABLE 10.—*Acre yield*[1] *of yellow dent corn from nearly disease-free seed, from Diplodia-infected seed, from Fusarium-infected seed, and from Cephalosporium-infected seed, untreated and treated, Waverly, Ill., 1928*

Kind of seed	Acre yield from untreated seed	Reduction in yield following use of diseased seed	Odds	Acre yield from treated seed	Increase in yield following seed treatment	Odds
	Bushels	*Bushels*		*Bushels*	*Bushels*	
Nearly disease-free	68.8			71.2	2.4	20:1
Diplodia-infected	54.7	14.1	1,257:1	68.0	13.3	4,132:1
Fusarium-infected	53.5	15.3	1,666:1	56.7	3.2	4:1
Cephalosporium-infected	59.3	9.5	8,699:1	61.7	2.4	13:1

[1] Average of 6 replications.

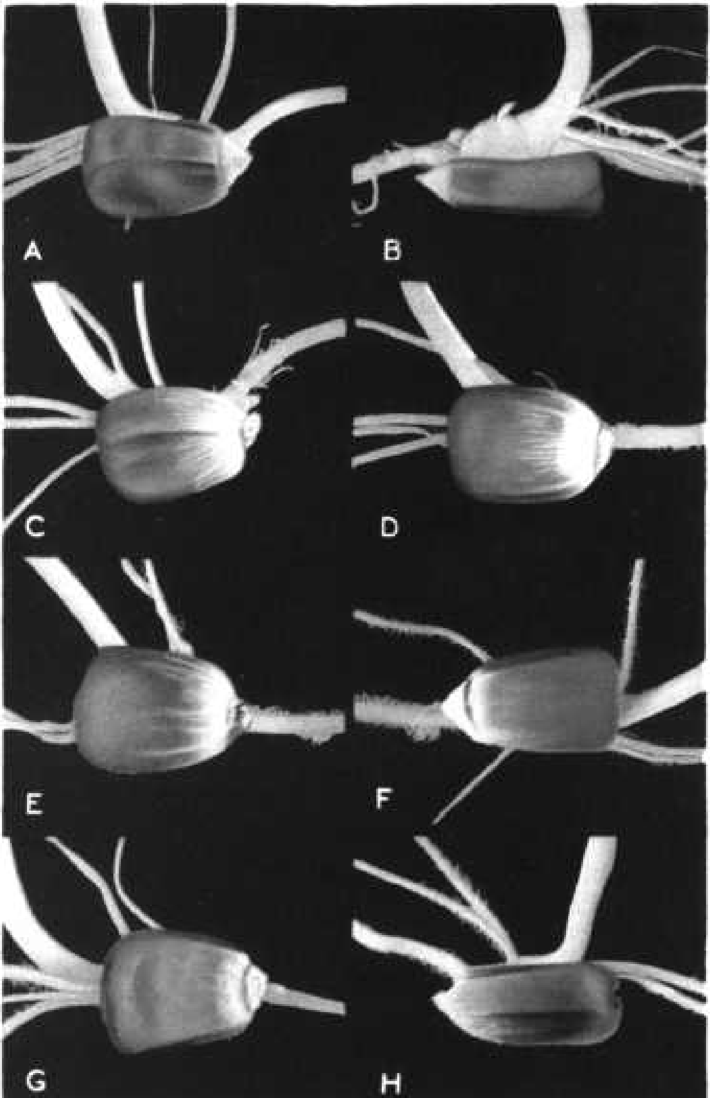
The extent to which *Fusarium moniliforme* may cause a high percentage of badly rotted ears and heavy seed infections seems to depend on a number of factors, most important of which is the genetic composition of the strain of corn involved. Sheldon first reported *F. moniliforme* as an ear-rot organism in eastern Nebraska. The senior writer, in company with A. G. Johnson, of the Division of Cereal Crops and Diseases, and James G. Dickson, previously mentioned, has observed fields of corn in eastern Nebraska in which there were heavy commercial losses from ear rots caused by *F. moniliforme.* Closely adjoining fields were inspected in which less than 1 per cent of the ears were rotted. Fusarium ear rots were found in appreciable amounts also in eastern Kansas, Missouri, and south-central Illinois. In the southern half of the upper Mississippi Valley Corn Belt, whole ears rotted by *F. moniliforme* are found more frequently than in the northern half of this same area, where *F. moniliforme* causes more kernel rot than ear rot.

In general, the roughly dented and starchy types of corn are more susceptible to Fusarium ear rot and seed infection than are the smoother and more horny types.

It seems probable, therefore, that corn from Fusarium-infected seed is low in yielding capacity not only because of injuries produced by the seed-borne infection but also on account of the inferior genetic make-up of the individual plant or strain, which may have made the seed infection possible. This interpretation is given further support by the frequent occurrence of Fusarium seed infection in much greater abundance on low-yielding recombinations than on high-yielding recombinations of hybrid corn. Seed treatment has not consistently increased the yield of corn from Fusarium-infected seed of low-yielding and disease-susceptible strains.

CEPHALOSPORIUM (BLACK-BUNDLE DISEASE)

Cephalosporium acremonium Corda is another disease-producing organism affecting corn. It is seed borne, but differs considerably from the others in that it causes a systemic infection of the corn plant. It does not cause seedling blight, nor does it ordinarily cause greatly reduced vigor of the seedlings. It may seriously reduce the



RESULTS OF SEED-TREATMENT EXPERIMENTS FOR DENT CORN

Germinating kernels uninfected and infected with *Cephalosporium acremonium* and *Fusarium moniliforme*. A, B.—Apparently disease-free corn kernels after germinating for seven days on a limestone-sawdust germinator at 82° F. C, D, E.—Kernels infected with *C. acremonium*. The fungus is pale pink in color and is externally evident on the tip end of the kernel only where it appears as a very fine downy growth. When the germinator is not kept too moist, the white streaks here shown usually develop along the seed coat of badly infected kernels. F, G, H.—Kernels infected with *F. moniliforme*. This fungus also begins growth at the tip end of the kernels, but sometimes it covers a little larger area than Cephalosporium. The color is pale pink also, but sometimes the texture is decidedly different, being more grainy in Fusarium. No white streaks are caused by this fungus.

yield of the corn crop, nevertheless, in that it may check normal ear development (*13*).

The symptoms on the germinator are at times difficult to distinguish from those caused by *Fusarium moniliforme*. In either case there is a pale pink fungus at the tip end of the kernel. A microscopic examination of the fungous growth on the kernel, characteristics of which are shown in Figure 4, is necessary for identification. When infection is severe and the germinator is kept only moderately moist, white streaks frequently develop under the seed coat at the back and sides of the infected kernels, as shown in Plate 2. When such streaks do not occur in the dry seed but first develop during the germination test, they can be accepted as a fairly reliable symptom of Cephalosporium infection.

Corn grown from Cephalosporium-infected seed composites selected from various seed lots and from different sections of the Corn Belt vary greatly in performance and yield as compared with corn grown from nearly disease-free seed composites from the same seed lots. On productive soil, corn from a few Cephalosporium-infected seed composites occasionally has yielded slightly better than corn from nearly disease-free seed of the same strain. On the other hand, corn from other Cephalosporium-infected seed composites, planted in sections where this disease apparently is more destructive, particularly in the southern part of the upper Mississippi Valley Corn Belt, has produced very inferior yields, as compared with the yields of corn from nearly disease-free seed of the same strain. (Table 10 and fig. 5.) As mentioned above in the discussion of the Fusarium disease, the nearly disease-free seed used in this experiment probably was disease-free because it has been produced on plants highly resistant to the black-bundle and other diseases.

Many factors may, and probably do, contribute to such wide differences in performance of corn from various lots of Cephalosporium-infected seed and from nearly disease-free seed. In the first place, strains of corn differ greatly in their reaction to this corn pathogene, some being very susceptible and others highly resistant. The soil environment in which the plants are growing is a very important factor. Corn on soil lacking in available phosphates or on soil having an excess of available nitrates seems to be much more susceptible to injury from the black-bundle disease than corn from the same seed selections on soil in which a good physiologic balance exists.

The percentage of plants showing conspicuous symptoms of this disease in corn from the same lots of nearly disease-free seed planted in various sections of the Corn Belt has varied from traces to as much as 40 per cent the same season. In closely adjacent fields, planted at approximately the same time from the same lot of nearly disease-free seed, corn in fields in which corn had been grown for the previous two or more years has consistently had much higher percentages of plants with conspicuous symptoms associated with this disease than corn in fields in which the corn has followed some other crop.

In 1927 a Cephalosporium-susceptible strain of corn was included in each of two experimental plots, A and B. The seed used tested nearly disease-free and, in addition, was given a seed treatment. Experimental plot A was on soil that had been cropped with corn the previous two years. Prior to planting, the soil received an application of a complete fertilizer (4–16–4) at the rate of 500 pounds per acre. Experimental plot B was on soil that had not grown a corn crop for the previous six years. In plot A every plant of the susceptible strain of corn was badly injured by the black-bundle disease. Plants of resistant strains in this same plot showed little evidence of the disease and produced high yields. In plot B very little evidence of the disease could be observed in the susceptible strain and there was very little Cephalosporium infection in the seed harvested from the susceptible strain. In the Cephalosporium-susceptible strain not a single Cephalosporium-free ear was found in the more than 400 ears harvested from plot A.

These results indicate soil infestation. Seed treatment may be of value on Cephalosporium-infected seed in controlling injuries resulting from seed-borne infection, but seed treatment has not been found effective in reducing losses from the black-bundle disease in corn planted on soil and in sections where this disease is destructive.

Although the black-bundle disease is widely distributed, the losses resulting from it are much greater in the southern part of the upper Mississippi Valley than in the northern part. Apparently some varieties are highly tolerant to this disease, particularly in the northern part of the Corn Belt, and the presence of Cephalosporium on the seed and within the plant does not seem to be associated with barrenness and nubbin production. The reasons for this are not fully understood.

Varieties susceptible to the black-bundle disease are not necessarily varieties or strains of low-yielding capacity and may produce satisfactory yields under conditions where this disease is less important. Some strains comparatively susceptible to this disease are highly resistant to the usual ear-rot diseases.

MISCELLANEOUS SEED-BORNE AND SOIL-BORNE DISEASES

That diseases of corn, other than those described above, exist and may cause reductions in both stand and early vigor under some field conditions seems evident. When the early planting of well-selected seed, known to be free from Diplodia, Gibberella, and Basisporium, is followed by a period of cold rainy weather, considerably reduced stands frequently result. The inability of a part of such seed to germinate and emerge can be attributed to unfavorable soil temperatures and soil moistures. Such an explanation, however, does not account for the beneficial influence of seed treatment in increasing stand and vigor under these conditions. The two lots of seed used in the experiment, the results from which are presented in Table 11, were not individually ear tested, but a composite germination test of 1,000 kernels from each seed lot showed that only traces of any of the now known seedling-blight organisms were present. Yet seed treatment increased the stands very markedly. The plant yields also were increased slightly.

TABLE 11.—*Field stands [1] and plant yields [1] from well-selected untested seed of two strains of yellow dent corn, each untreated and treated, Bloomington, Ill., 1927*

Strain	Final field stand from seed		Percentage rate of increase in stand following seed treatment	Odds	Plant yield from seed		Percentage rate of increase in plant yield following seed treatment	Odds
	Untreated	Treated			Untreated	Treated		
	Per cent	*Per cent*	*Per cent*		*Pound*	*Pound*	*Per cent*	
176-A	81.9	86.6	5.7	171:1	0.713	0.734	2.9	4:1
90-Day	76.6	86.5	12.9	>9,999:1	.617	.626	1.5	2:1

[1] Average of 16 replications.

Such beneficial effects following seed treatment are not confined to instances in which early planting is followed by unfavorable weather

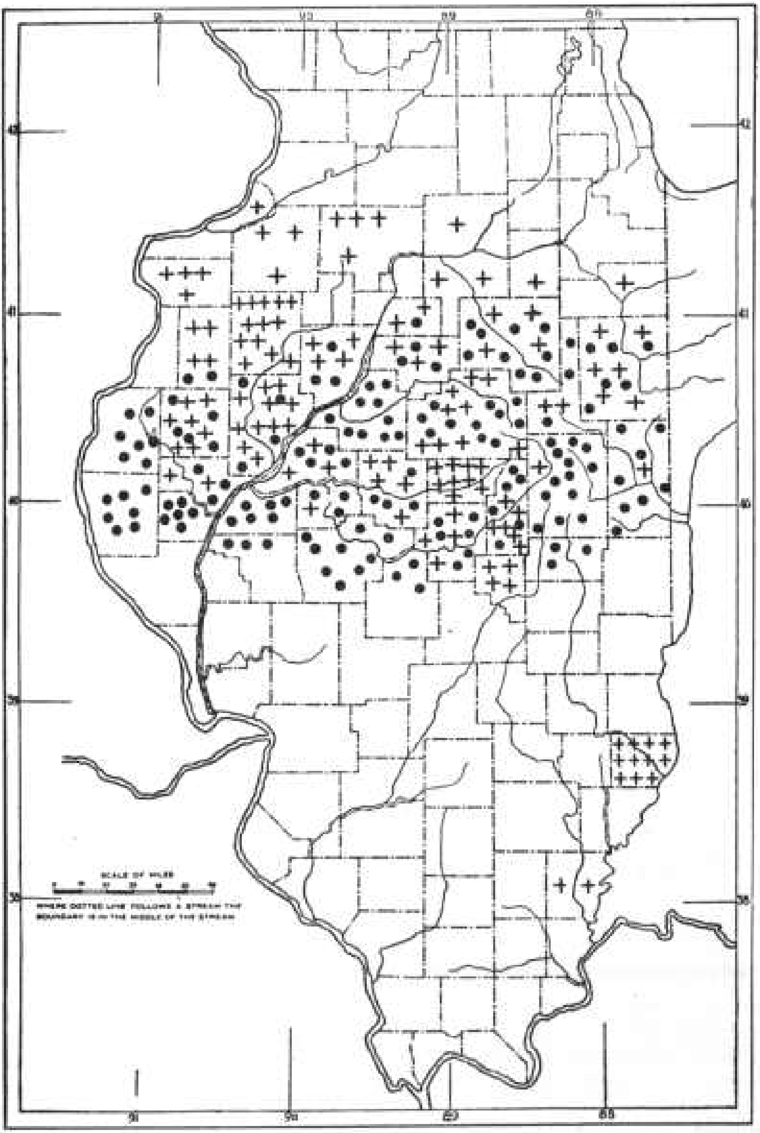


FIGURE 6.—Points in Illinois at which 285 planter-box collections were made. The collections secured at the points marked + were studied individually. The remaining collections were composited—80 in 1928 and 68 in 1929

conditions. Sometimes later plantings are followed by a period of warm rainy weather, and under these conditions substantial increases in stand and vigor may follow the use of seed treatment.

In the spring of 1928, samples of seed corn were collected from 285 farmers' planter boxes throughout central Illinois. (Fig. 6.) Of these samples 112 were planted separately in an experimental plot, 2 individual rows of 20 hills each, 2 kernels per hill, 1 row with untreated seed, and a second row with treated seed. The soil on which this experimental plot was located was unusually uniform, as judged by yields from a hybrid strain of corn planted in every fifth row for a soil check. This soil received a liberal broadcast application of a 4–16–4 fertilizer one week before planting. There was no lack of soil moisture at any time during the growing season. The level of productivity of the soil, as measured by the yields from the hybrid corn in every fifth row, was well above the average yield of the higher yielding planter-box collections. Data from 32 of these farmers' planter-box collections are presented in Table 12.

TABLE 12.—*Data on two groups, A and B, of yellow dent seed corn collected from farmers' planter boxes in the spring of 1928 and grown in experimental plots near Bloomington, Ill., 1928*

Items under observation	Group A (17 seed collections)	Group B (15 seed collections)
Laboratory germination data:		
Percentage of vitality	100.0	100.0
Percentage of kernels infected with Diplodia zeae and Gibberella saubinetii	0	0
Laboratory plating data:		
Percentage of clean kernels	42.4	29.3
Percentage infected with—		
Diplodia zeae	0	0
Gibberella saubinetii	0	0
Basisporium gallarum	18.8	17.3
Fusarium moniliforme	2.4	0
Cephalosporium acremonium	4.7	0
Other fungi	31.7	53.4
Field data:		
Stand from—		
Untreated seed ... per cent	87.7	70.9
Treated seed ... do	88.9	86.4
Percentage of increase in stand following treatment	1.4	21.9
Odds	13:1	>9,999:1
Plant yield from—		
Untreated seed ... pound	0.603	0.679
Treated seed ... do	.642	.622
Percentage of increase (+) or decrease (−) in plant yield following seed treatment	+6.5	−8.4
Odds	29:1	19:1
Acre yield from—		
Untreated seed ... bushels	50.2	45.0
Treated seed ... do	54.1	50.9
Increase in yield following seed treatment ... do	3.9	5.9
Odds	90:1	74:1

In studying the response to seed treatment of corn from 112 of the farmers' planter-box collections, referred to above, it was observed that the stand of a number of individual samples was not increased by seed treatment, while the stand of other samples was increased from 5 to 45 per cent by the same seed treatment. (Fig. 7.) Kernels from several lots, representing those whose field stand was not increased, Group A, and those whose field stand was increased, Group B, were placed on a limestone-sawdust germinator. The resulting germination test showed that the vitality of each group was satisfactory, each being 100 per cent in this particular germination test. Neither Diplodia nor Gibberella was present. (Table 12.) In plating kernels from each seed lot of these two groups, Helen Johann, of the Division of Cereal Crops and Diseases, and M. H. Harris, graduate student at the University of Wisconsin, obtained information concerning the seed infection. While neither Diplodia nor Gibberella was found, each group carried approximately the same

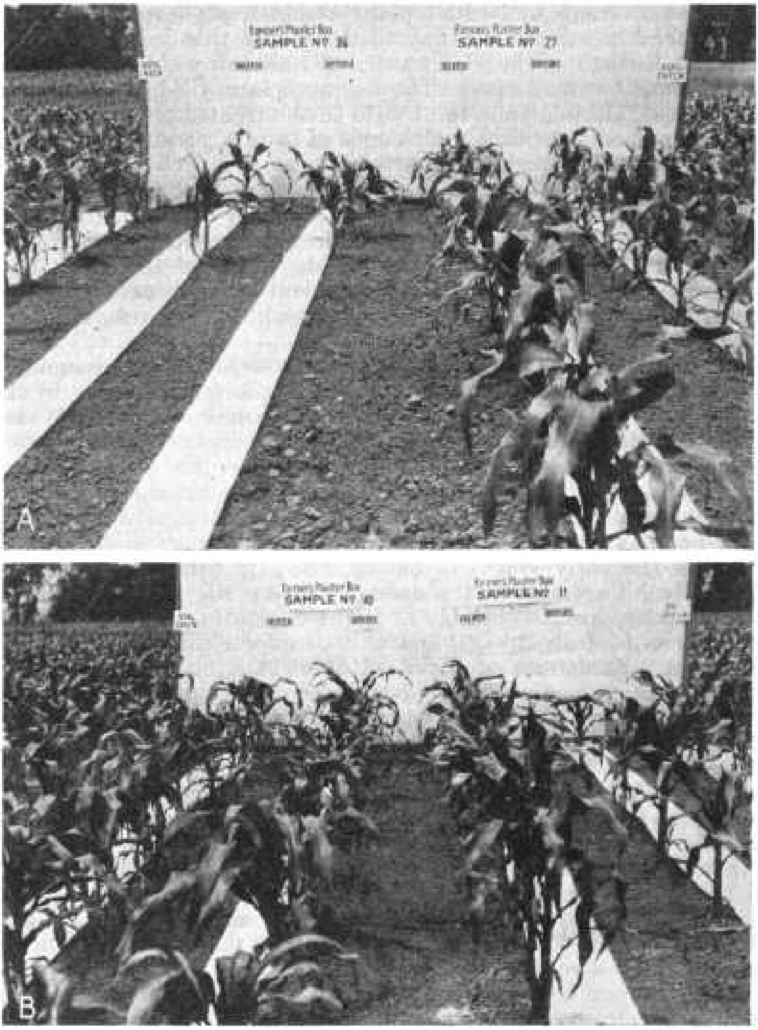


FIGURE 7.—Representative portions of rows of corn from different farmers' planter-box seed samples (A, Nos. 26 and 27; B, Nos. 10 and 11), treated and untreated, showing differences in response to seed treatment, Bloomington, Ill., 1929

percentage of Basisporium infection, namely, 18.8 and 17.3 per cent, respectively. Group A had 42.4 per cent clean kernels, as compared with 29.3 per cent clean kernels in Group B. The pathogenicity of the fungi called "other fungi" in Table 12 has not been determined.

Although the stand was not increased appreciably in the first group, there was a significant increase in individual plant yield and in the total yield, 3.9 bushels with odds of 90 to 1. Taken by itself, such behavior might be interpreted as seed stimulation. But such an interpretation would not adequately account for the behavior in the group whose stand was increased 21.9 per cent by seed treatment but whose average individual plant yields were decreased 8.4 per cent by seed treatment. Many of the plants that were enabled to survive as a result of the seed treatment were low yielders, producing only nubbins or small ears. The average plant yield, consequently, was reduced, although the total yield in the treated plots was significantly increased, 5.9 bushels with odds of 74 to 1, because of the great increase in stand.

These beneficial effects from seed treatment probably are due in part to the control of a miscellaneous group of organisms that may adhere to the corn kernel and may infect the seedling slightly, and also in part to a measure of protection that seed treatment may afford against injury from the attack of soil-borne disease-producing organisms under unfavorable environmental conditions following planting.

There are two general types of corn, which may be designated types A and B, that are most likely to be affected adversely by the above-discussed miscellaneous group of organisms. There are individual plants, both in open-pollinated varieties and in hybrid recombinations, that continue to function after the ear apparently is mature (type A). The ears on such plants retain excess moisture longer than do ears on plants that cease to function actively as soon as the ear has reached maturity. Either before harvesting for seed or during the early stages of curing, the ears from type A plants, apparently on account of the excess moisture they contain, and for other reasons, are susceptible to slight infections with this miscellaneous group of organisms, and also to infections by Diplodia and Gibberella. Seed from such type A plant ears, either when planted under conditions where these diseases do not affect adversely the growth of the resulting corn plants or when given a suitable seed treatment, has produced satisfactory yields.

In contrast to the type A plants, there are other plants that are unable to effect complete physiologic maturity on account of their inability to function properly under adverse environmental conditions (type B). These plants either may continue to function only slowly as they approach maturity or even may be killed prematurely by a fall in temperature which may not necessarily go as low as 0° C. When seed is selected in the early fall, many ears from type B plants externally appear to be as good as more fully matured ears from the physiologically stronger type A plants. When seed is not harvested until late, ears on both type A and type B plants may become infected. Plants grown from seed produced on type B plants are likely, however, to be more susceptible to injury resulting from unfavorable soil environment immediately following planting, and also more susceptible to injury resulting from unfavorable environmental conditions as they approach maturity, than corresponding plants from seed of type A plant origin.

In interpreting a germination test, seed ears from both of the two types of corn plants discussed above often are classed as slightly diseased. Ears from type A plants may become slightly infected because the mother plants are slow in bringing to completion the very last stages of the maturation process. Ears from type B plants may show slight infection because the mother plants are unable to complete ear development and maturation under the particular environment in which they are grown. This inability may be due either to nonparasitic physiologic weakness or to disease. Ears from type A plants have the luster, well-filled kernels, horny endosperm, and heavy weight in relation to size that usually accompany full maturity. Ears from type B plants usually lack one or more of these desirable ear and kernel characteristics. The effect of the slightly diseased condition on yield is shown in the experimental results that follow.

In the spring of 1928 a lot of approximately 400 bushels of yellow dent seed corn was tested in the germinator and separated, on the basis of germinator behavior, into nearly disease-free (grade 1), slightly diseased (grade 2), and badly diseased or dead (grade 3). Random samples of approximately 15 bushels each were taken from grades 1 and 2. Composites of shelled corn representing these two grades were obtained by removing two or three rows of kernels from each ear in the random samples. The random sample representing the slightly diseased seed, grade 2, was further selected by picking out the better appearing ears. From these selected ears a composite of shelled seed also was obtained by removing another two rows of kernels. This composite was designated grade 2 reselected. Untreated and treated seed lots representing the slightly diseased seed (grade 2 unselected) and the better appearing slightly diseased seed (grade 2 reselected) and an untreated lot representing the nearly disease-free seed were planted in a field experiment. The yield data from this experiment are given in Table 13.

The yield from the untreated slightly diseased seed (grade 2 unselected) was significantly less than the yield of the nearly disease-free seed, 61.6 bushels as compared with 69.4 bushels. Untreated seed from the better appearing slightly diseased ears (grade 2 reselected) produced 65.9 bushels, as compared with 61.6 bushels from the untreated, unselected, slightly diseased seed. Unselected slightly diseased seed when treated produced 63.9 bushels, while reselected slightly diseased seed when treated produced 69.0 bushels. The latter yield compares favorably with the yield from untreated nearly disease-free seed, 69.4 bushels.

TABLE 13.—*Acre yields* [1] *of yellow dent corn, strain 176–A, from untreated nearly disease-free seed and from untreated and treated unselected and selected seed slightly diseased on the germinator, planted near Bloomington, Ill., May 2, 1928*

Kind of seed	Seed treatment	Acre yield	Increase in yield following seed treatment	Odds
		Bushels	*Bushels*	
Nearly disease-free (grade 1)	Untreated	69.4		
Better appearing, slightly diseased ears (grade 2 reselected)	do	65.9		
	Treated	69.0	3.1	137:1
Slightly diseased (grade 2 unselected)	Untreated	61.6		
	Treated	63.9	2.3	28:1

[1] Average of 20 replications.

MATERIALS AND METHODS

SEED DISINFECTANTS

More than 200 different seed disinfectants were used in preliminary experiments. Approximately half of that number were included in field experiments. A list of the compounds used as toxic ingredients in different concentrations and in combination with different activators and different carriers, chiefly talc and lime, follows:

COMPOUNDS USED IN WATER SOLUTIONS OR SUSPENSIONS

Acetoxymercuriorthonitrophenol.
Anthracene emulsion.
Bordeaux mixture.
Calcium hypochlorite (chlorinated lime).
Copper salt in miscible oil.
Copper sulphate.
Cyanmercurichlorophenol.
Formaldehyde.
Hydroxymercuriorthonitrophenol.
Hydroxymercurichlorophenol.
Hydroxymercuriorthochlorophenol.
Hydroxymercurimetacresol.
Mercuric chloride.
Mercuric thiocyanate.
Water.

COMPOUNDS USED AS DUSTS

Basic mercuric acetate.
Cyanmercuricresol.
Copper stearate.
Copper salicylate.
Copper carbonate.
"Dritomic" sulphur.
Dinitrophenol.
Ethyl mercury chloride.
Hydroxymercurinitrophenol.
Hydroxymercuriorthonitrophenol.
Hydroxymercuricresol.
Hydroxymercurichlorophenol.
Hydroxymercuriparanitrophenol.
Hydroxymercurimetacresol.
Lead arsenate.
Lead oxide.
Mercurized furfuramid.
Mercuric amino chloride.
Mercuric chloride.
Mercurous chloride.
Mercuric oxide.
Mercurized hexamine.
Mercurized hexamethylenetetramine.
Mercuric thiocyanate.
Metallic mercury (in talc.)
Mercurized acetaldehyde.
Mixtures of mercuric and mercurous chloride.
Mixtures of hydroxymercurichlorophenol and hydroxymercurinitrophenol.
Mixture of hydroxymercurichlorophenol and hydroxymercuricuprinitrophenol.
Mixture of mercuric chloride and mercuric iodide.
Mixture of calcium sulphate and sodium fluosilicate.
Mixture of calcium sulphate and colloidal copper.
Paraformaldehyde.

No attempt will be made to present the detailed data on all of the many compounds that for various reasons were found unsatisfactory. The experimental seed-disinfectant compounds reported on are designated by chemical names, and commercially available seed disinfectants are designated by both proprietary name and the chemical composition of the toxic ingredient.

The following commercially distributed disinfectants were used:[4]

BAYER DUST

Hydroxymercurinitrophenol sulphate	4 per cent
Inert material	96 per cent

Formerly produced by the Bayer Co. (Inc.), New York, N. Y.

[4] Names are furnished merely as information, and with no recommendation of the firms or their wares or any guaranty of their business standing or financial responsibility. In most instances information as to the chemical nature of the active ingredient of experimental products was supplied by the manufacturers at the time the products were submitted for experimentation. Chemists of the Bureau of Chemistry and Soils, United States Department of Agriculture, analyzed the majority of the more promising experimental seed-disinfectant compounds. The identity and chemical names of the active ingredients of many of the compounds, results from the use of which are reported in this bulletin, are based largely on the information supplied by the Bureau of Chemistry and Soils, through the courtesy of C. C. McDonnell, Acting Chief of the Miscellaneous Division.

IMPROVED SEMESAN JR. (DU PONT DUST NO. 35–C)

Hydroxymercuricresol	12 per cent
Inert material	88 per cent

Produced by the Bayer–Semesan Co. (Inc.), New York, N. Y.

MERKO

Mercury (metallic)	Not less than 3.5 per cent
Inert ingredients	Not more than 96.5 per cent

Produced by the Corona Chemical Division, Pittsburgh Plate Glass Co., Milwaukee, Wis.

STEROCIDE

Mercury furfuramid	4 per cent
Inactive ingredients	96 per cent

Produced by the Roessler & Hasslacher Chemical Co., New York, N. Y.

In addition to the above, results are reported from the use of one dust disinfectant of foreign manufacture which is not commercially available in this country. Its laboratory designation and chemical composition supplied by the manufacturer, later verified by the Bureau of Chemistry and Soils, are as follows:

S. F. A. NO. 225

Cyanmercuricresol	12 per cent

Produced by the Saccharin-Fabrik, Aktiengesellschaft, Vorm. Fahlberg, List & Co., Magdeburg-Südost, Germany.

APPLYING SEED DISINFECTANTS

The liquid treatments were applied by soaking the seed in water solutions or suspensions of the compounds. Many of the preliminary liquid treatments were applied in the temperature-control chambers of the plant physiology greenhouses of the University of Illinois, through the courtesy of Charles F. Hottes, to determine the effects of different temperatures with different concentrations during the time of treatment. The most consistent results were obtained at about 30° C. for a period of one and one-half hours using a concentration of 0.50 per cent for hydroxymercurichlorophenol and hydroxymercuriorthonitrophenol and 0.15 per cent for acetoxymercuriorthonitrophenol. (Table 14.) Therefore, unless otherwise stated, this temperature and time were used in applying the liquid treatments. For the most part the seed to be treated was put into beakers containing the solutions. At the end of the period of treatment the solutions were poured off and discarded. The wet seed lots were placed on blotters in a warm room or on greenhouse benches to dry. In some instances the corn was put in cheesecloth sacks during treatment, after which the sacks containing the seed were hung on a wire so that the treatment solution could drain off.

TABLE 14.—*Effect on the control of Diplodia seedling blight of corn produced by soaking seed at four different temperatures for one and one-half hours in water and in three concentrations of hydroxymercurichlorophenol, acetoxymercuriorthonitrophenol, and hydroxymercuriorthonitrophenol, University of Illinois, 1925*

Toxic ingredient of seed-treatment solution	Temperature of soak	Concentration of toxic ingredient in solution	Mean percentage of germination [1]	Mean green weight of tops [1]	Mean percentage of plants with mesocotyls showing no rotting [1]
	° C.	*Per cent*	*Per cent*	*Grams*	*Per cent*
No treatment			82.4	6.2	0.8
Water	10		82.8	11.1	11.7
	20		84.0	6.3	.7
	30		86.8	3.8	
Hydroxymercurichlorophenol	10	.25	85.2	19.1	50.3
		.50	90.0	23.4	77.8
		.75	88.8	420.6	92.4
	20	.25	84.0	18.3	62.9
		.50	77.2	18.7	85.1
		.75	82.0	21.0	81.5
	30	.25	90.8	23.0	67.8
		.50	90.8	25.7	90.8
		.75	90.8	22.4	86.8
	35	.25	88.0	20.4	72.8
		.50	92.8	18.3	88.8
		.75	93.2	22.8	94.4
Acetoxymercuriorthonitrophenol	10	.10	91.2	22.6	77.4
		.15	86.0	25.2	86.9
		.25	95.2	23.0	87.4
	20	.10	84.0	20.1	74.9
		.15	76.0	23.2	86.5
		.25	86.8	23.0	85.2
	30	.10	89.2	25.6	86.2
		.15	90.8	25.2	90.3
		.25	90.8	21.2	96.9
	35	.10	91.2	21.0	96.1
		.15	92.0	17.6	94.0
		.25	93.2	17.8	89.3
Hydroxymercuriorthonitrophenol	10	.25	88.8	20.8	73.4
		.50	85.2	22.1	93.5
		.75	91.2	20.8	60.4
	20	.25	80.0	16.3	68.5
		.50	82.0	17.3	91.6
		.75	83.2	20.9	89.5
	30	.25	85.2	25.0	75.8
		.50	88.8	27.8	90.9
		.75	94.0	24.6	64.7
	35	.25	89.2	16.9	66.8
		.50	88.8	20.9	94.9
		.75	90.0	19.3	83.1

[1] Averages of results from young corn plants growing in 10 pots in each of which 25 seeds had been planted, the greenhouse temperatures being 22°-24° C.

Dust disinfectants were applied by shaking the seed and the dust disinfectant in a pint or quart Mason jar for a period of 5 to 10 minutes, after which excess dust not adhering to the surface of the kernels was screened off. For the experiments conducted in 1927, 1928, and 1929 all the seed lots were treated by the equipment illustrated in Figure 8. For each series of dust treatments the frame holding the quart jars was rotated at the rate of 28 revolutions per minute for a period of 20 minutes by means of an electric motor. All excess dust was removed before the seed was repacketed. Such a machine makes possible a more uniform and comparable application of a large number of treatments with different dusts. It also saves considerable time and labor when there are several hundred small samples to be treated.

Larger lots of seed for machine planting were treated in a barrel churn. The excess dust was removed by allowing the grain to run down an inclined screen, as illustrated in Figure 9. One or the other of these machines is satisfactory for treating small lots of seed for planting in breeding nurseries, in varietal experiments, or in other experimental field plots for which relatively small quantities of uniformly treated seed are desired.

VARIETIES OF CORN AND SEED SELECTIONS

Seed of several standard, open-pollinated varieties, widely grown throughout central Illinois, was used in the experiments the results of which are reported in this bulletin. Among these varieties may be mentioned University of Illinois Yellow Dent, Funk's Yellow Dent Strain 176–A, Krug Yellow Dent, Will County Favorite, Golden King, Funk's Ninety-Day, Griffith Early Dent, a first-generation cross known as F_1–250, a crossbred strain known as 517, and seed collected from planter boxes of 267 farmers in central Illinois, representing seed from approximately 50 counties.

Two principal standards were used for evaluating the various seed disinfectants. These were (1) the effectiveness of any disinfectant in

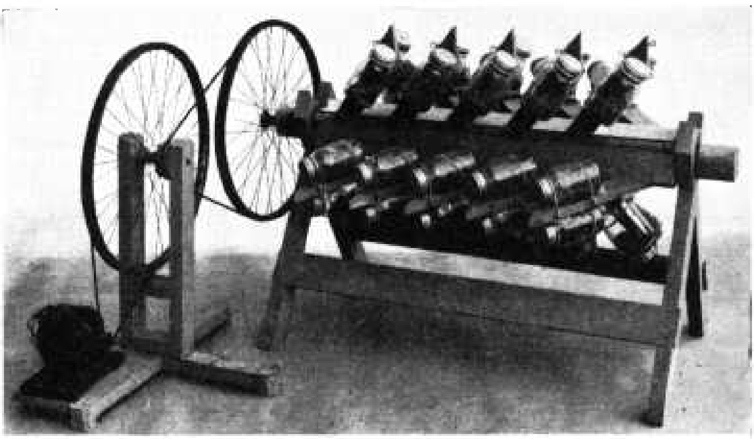


FIGURE 8.—Equipment used for applying dust disinfectants to small quantities of seed corn

controlling seed-borne seedling blight diseases, and (2) the effect of the disinfectant on the growth and yield of corn from high-quality seed. By seed selection based on plant, ear, and kernel characters and by the use of the germinator, seed lots were prepared that were nearly disease free with reference to seed-borne diseases. Different seed lots also were prepared that were susceptible to scutellum rot on the germinator and that were naturally infected with *Diplodia zeae*, with *Gibberella saubinetii*, with *Basisporium gallarum*, with *Fusarium moniliforme*, and with *Cephalosporium acremonium*, respectively. These seed lots have been designated as scutellum-rot susceptible, Diplodia-infected, Gibberella-infected, Basisporium-infected, Fusarium-infected, and Cephalosporium-infected, respectively. The use of these specially prepared composites has been found valuable in the study of a number of seed-treatment problems.

All nearly disease-free seed lots were from ears that had been selected on the basis of ear and kernel characters known to be associated with better seed prior to having been subjected to the germination test. In many cases these ears had been selected from erect plants that showed no evidence of disease. These seed lots might properly be considered good seed and have been designated in the tables both as "nearly disease-free" and as "good tested." Other seed lots that were selected with equal care, but which were not given the additional selection based on their record in the germination test, have been designated as "good untested."

A few seed lots were prepared by using the germination test to eliminate only the dead and partly dead ears. These seed lots did not have the benefit of the selection with reference to ear and kernel characters which was given the "good tested" and "good untested" seed lots. They have been designated as "average seed."

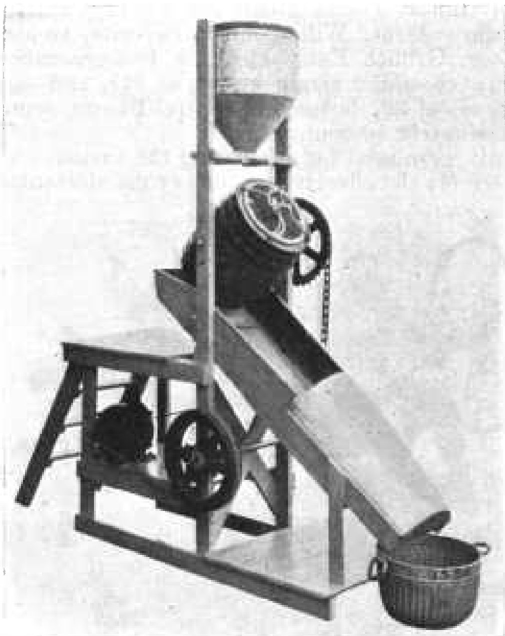


FIGURE 9.—Equipment used for applying dust disinfectants to larger quantities of seed then can be treated conveniently by the equipment illustrated in Figure 8. The excess dust is screened off before the seed reaches the tub

In 1928 and 1929, 285 samples were collected in central Illinois from planters during the corn-planting season. The points at which planter-box samples were collected are indicated in Figure 6. A composite of 80 of these planter-box samples in 1928 and a composite of 68 samples in 1929 have been designated as "average farmers' seed."

METHODS OF OBTAINING DISEASED-SEED COMPOSITES

Through the courtesy of the Funk Bros. Seed Co., a supply of good-appearing but diseased ears was made available each year for experimental use. For the most part the diseased ears were classified according to the fungi with which they were primarily infected. After further selection these ears were tagged and numbered. Twenty kernels from each diseased ear, 10 from each side, were placed on the germinator in two parallel rows, the kernels being placed on the germinator in the same order in which they were removed from the ear, starting at the butt of the ear and ending at the tip.

In reading the germination test for the selection of Diplodia, Gibberella, and Basisporium composites, respectively, only the ears or parts of ears were taken that were viable and also infected with the respective fungi. The determinations of Fusarium and Cephalosporium infections were checked by the aid of a microscope. Ears bearing more than one of the diseases under investigation were rejected.

Prior to packeting, the different seed composites were run through a grader to remove small, thin, and light kernels. Germination records of some of these diseased composites used in the experiments conducted in 1927 are given in Table 15.

TABLE 15.—*Condition of composite seed samples of yellow dent corn used in the 1927 experiments, percentages being based on germination tests of 500 kernels from each seed lot*

Composites	Viability	Seedlings apparently disease-free	Kernels showing visible infection with—					Germinating kernels scutellum-rot susceptible [1]
			Diplodia	Gibberella	Basisporium	Fusarium	Cephalosporium	
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
Nearly disease-free	99.6	92.2	2.6	1.0	0	1.4	1.6	0.8
Diplodia	94.8	.6	91.0	1.6	0	.4	-------	1.2
Gibberella	95.0	.8	1.8	88.8	0	-------	2.4	1.2
Basisporium	99.0	0	.8	2.0	93.0	1.4	-------	1.8
Fusarium	98.2	1.0	2.6	2.4	0	85.2	4.0	3.0
Cephalosporium	98.2	9.2	.6	4.0	0	.8	82.0	1.6
Scutellum-rot susceptible	98.6	9.0	2.4	.6	-------	19.6	8.2	58.8

[1] For a further description of scutellum-rot susceptible seedlings, the reader is referred to the discussion in Illinois Bulletin 255 (*2*) and the paper by Koehler (*7*).

LABORATORY AND GREENHOUSE METHODS

For preliminary laboratory and greenhouse experiments extensive use was made at first of gallon jars, the lower two-thirds of each of which was filled with soil and the upper one-third with sand. The untreated and treated seed were planted in the wet sand and then covered with dry sand. By having the soil and the sand in which the kernels were planted thoroughly moist, so that water drained from a drainage hole at the bottom of the container (the drain hole was stoppered afterwards) before the kernels were covered with dry sand, it was not found necessary to add additional water to the jars until the corn seedlings were 4 or 5 inches high. After the corn was thus planted, the drainage holes of the jars were stoppered. The roots of seedlings not badly affected with *Diplodia zeae* or *Gibberella saubinetii* penetrated the 1½ to 2 inches of sand to the soil, after which they made good growth. The roots of seedlings badly affected with seedling blight seldom reached the soil, and consequently the seedlings succumbed in a short time. The sand permitted a rapid washing out of the crowns of the young plants preparatory to a close examination of the mesocotyls. This method accentuated both the effects of the disease and the value of the seed treatment. However, this method was found very satisfactory for preliminary work in determining the fungicidal value of a large number of compounds, particularly with Diplodia-infected seed. Later a modification of this method was used and described by Reddy and Holbert (*15*).

Very useful preliminary data on the fungicidal value of various compounds have been obtained by another modification of the method described above. Only sand was used in the gallon jars, and the drain hole at the bottom was stoppered with glass wool. By setting a series of such jars in a large shallow pan of water a comparatively even moisture content can be maintained if the seeds are planted at a uniform height from the water level. A height of 4½ to 5 inches gives a moisture content very favorable for the development of Diplodia seedling blight. The arrangement and operation of this equipment is illustrated in Figure 10. Such equipment may be used in any well-heated room with a temperature of 16° to 22° C. to determine whether or not a seed disinfectant has sufficient merit to justify further experimentation.

Diplodia seedling blight is perhaps more easily and definitely controlled by seed treatment than any other seed-borne seedling-blight

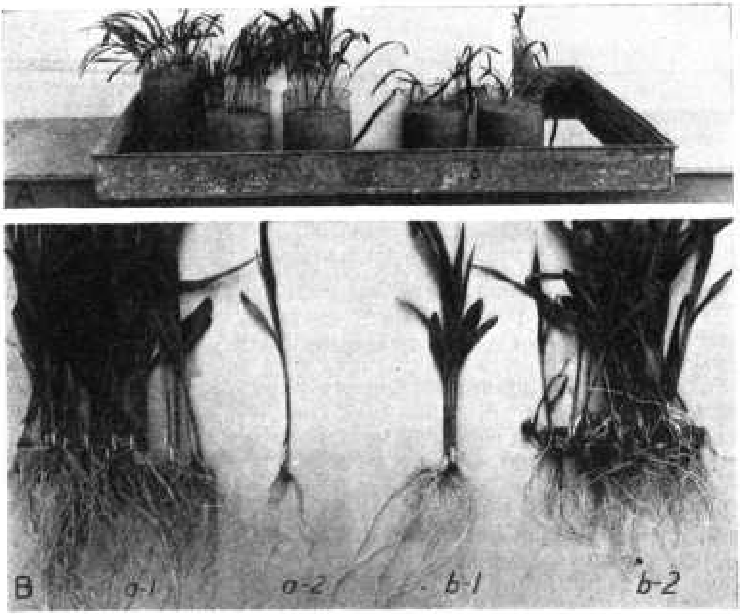


FIGURE 10.—A, Apparatus used in securing preliminary information regarding the fungicidal value of dust disinfectants, using Diplodia-infected seed, *a*, treated, and *b*, untreated. The large pan contains water. The glass jars have a hole in the side at the bottom, stoppered with glass wool, and contain sand, as explained in the text. B, Seedlings removed from the sand in the jars shown in A: *a*–1, Seed treated, seedlings healthy; *a*–2, seed treated, seedlings diseased; *b*–1, seed not treated, seedlings healthy; *b*–2, seed not treated, seedlings diseased

disease of corn. On this account Diplodia-infected seed was used extensively in preliminary experiments. In such work there is much advantage, from the standpoint of securing accurate results rather quickly, in maintaining temperatures and moistures that favor the maximum development of this disease. Data presented in Tables 1 and 2 show that the germination and growth of corn from Diplodia-infected seed is influenced very largely by changes in either temperature or moisture. In the data shown in Table 1 there was an increase in germination from 36.0 per cent at 10° C. to 80.8 per cent at 30°. At the lower temperatures the difference between untreated and treated Diplodia-infected seed was in the germination percentage, but above 25° the difference was largely in the percentage of seedling blight. In view of these facts, and also of the fact that a relatively high soil-moisture content favors the development of Diplodia seedling blight (Table 2), preliminary experiments in the laboratory and greenhouse with various seed-treatment compounds were conducted by growing corn from treated and from untreated Diplodia-infected seed in pots, as described above, a high soil-moisture content, 60 to 65 per cent of moisture-holding capacity, at a temperature of 22° to 25° being maintained.

METHODS USED IN FIELD EXPERIMENTS

Laboratory and greenhouse experiments with seed-treatment compounds are invaluable for the purpose of eliminating those compounds which are too low in fungicidal value and also those which may have a marked depressing effect upon the growth of corn seedlings. The use of some disinfectants that have stood comparatively high in all the laboratory and greenhouse studies, however, has had a significantly detrimental effect on the yield of corn from good seed. A few seed disinfectants that have never given the highest disease control under laboratory conditions have stood consistently high in almost all field experiments. The yield of some strains of corn has been benefited remarkably by certain seed-treatment compounds, while the yield of other strains of corn, comparable in seed condition, has been reduced significantly by treatment with the same compounds. Again, soil and climatic conditions have an important influence on the final effect of seed treatments on yield of grain. From these considerations it seems evident that the value of different seed disinfectants in giving partial disease control and in influencing yield must be established by repeated field experiments that include a wide range of soil and climatic conditions over a period of years and, preferably, with several strains of corn.

Two different types of field-plot arrangement have been used, namely, the single or 2-row plots, 24 to 40 hills in length (84 to 140 feet), and the rectangular plots, 3 to 5 hills wide and 8 to 10 hills long. In either arrangement of individual plots an untreated check was always contiguous to a plot planted with treated seed. In most of the field experiments conducted in 1927 and prior to that date the plots were replicated eight times. In a few instances 10 and 12 replications were used. In the experiments conducted in 1928 and in 1929, 8, 10, 12, 16, and 20 replications were used. Undoubtedly there are some distinct advantages in the larger number of replications.

The use of diseased seed adds considerably to the variability in the acre yield from the untreated checks (Table 16). Corn grown from diseased seed is more susceptible to injury from unfavorable soil environment than is corn grown from good seed. In each of the three varieties mentioned in Table 16 there is less variability in the yield of corn from untreated nearly disease-free seed than from the untreated diseased-seed lots. Seed treatment reduced variability in yield of corn from both nearly disease-free seed and from diseased seed in nearly every instance. (Tables 16 and 17.) In series 9 and 10 in Table 16, where there were a few poorly drained spots, seed treatment reduced the variability in acre yield of corn from good seed from 7.6 per cent to 5.0 per cent and from 9.4 per cent to 4.5 per cent.

The effect of seed treatment in reducing variability in yield of corn from good seed, even on well-drained productive soil, has been observed very often. This reduction of variability in yield from treated seed may be due in part to a protective action of the seed treatment in preventing injury from soil organisms and also to the uniformly higher field stands from treated seed than from untreated seed.

TABLE 16.—*Variability in acre yield of yellow dent corn from untreated and treated nearly disease-free seed and from untreated and treated seed infected with Diplodia, Gibberella, and Basisporium, respectively, Bloomington, Ill., 1927*

Variety	Series	Seed condition	Variability in acre yield from seed—		Variation in acre yield from treated seed of a first-generation cross used as a soil check in every fifth row
			Untreated	Treated	
			Per cent	*Per cent*	*Per cent*
176-A	1	Nearly disease-free [1]	16.3	8.0	4.8
	2	do	5.4	4.2	3.2
	3	Diplodia-infected	21.8	10.0	5.5
	4	Gibberella-infected	16.4	11.7	6.6
	5	Basisporium-infected	10.4	8.5	6.3
F_1-250	6	Nearly disease-free	3.2	5.0	
	7	Diplodia-infected	11.2	5.4	
	8	Basisporium-infected	8.7	6.9	5.6
90-Day	9	Nearly disease-free	7.6	5.0	
	10	Good untested	9.4	4.5	
	11	Diseased	14.8	6.2	

[1] This series had a much higher percentage of lodged plants than series 2 planted from the same seed lot

TABLE 17.—*Variability in acre yield of yellow dent corn from untreated and treated nearly disease-free seed and from untreated and treated seed infected with Diplodia and Gibberella, respectively, Bloomington, Ill., 1928 and 1929*

Variety	Series	Seed condition	Variability in acre yield from seed—	
			Untreated	Treated
			Per cent	*Per cent*
90-Day	[1] 1	Nearly disease-free		6.3
Do	2	Diplodia-infected	13.8	9.4
Do	[1] 3	Nearly disease-free		7.4
Do	4	Gibberella-infected	19.1	9.3
Commercial hybrid 250	5	Diplodia-infected	16.8	8.4

[1] Soil check.

In experiments where there are wide variations in the yields from plots of corn grown from untreated seed and where it is desired to compare a number of seed-treatment compounds, frequently occurring soil checks planted with good seed are very essential. Soil checks in which nearly disease-free seed has been used furnish a basis for correcting the widely varying yields of individual plots from untreated seed, especially from diseased seed. Since the use of seed treatment may reduce still further the variation in the yield of plots planted with good seed (Tables 16 and 17), the seed used for planting the soil checks was treated with cyanmercuricresol (S. F. A. No. 225). This dust disinfectant was chosen as a treatment for soil checks because it is one of the best treatments for corn, and also because it was not on the American market in competition with other dust disinfectants.

Where it is desirable to compare the effects of a number of seed treatments on several selections of corn, the use of treated nearly disease-free seed of a well-selected strain of corn to serve as a soil check is very necessary. In many of the experiments every fifth plot was planted with treated nearly disease-free seed of a good first-generation cross, the intervening four plots being planted with an untreated check, two treated plots, and a second untreated check. The data presented in Table 16 are from an experiment having such a planting plan. There was much less variability in the yield of the soil check in every fifth row planted with a first-generation cross than there was in the yield of the untreated and treated seed planted in the intervening rows.

Another arrangement that proved equally satisfactory, and in some respects more so, was as follows:

Plot 1. Soil check.
Plot 2. Untreated seed.
Plot 3. Soil check.
Plots 4–6. Treated seed.
Plot 7. Soil check.
Plot 8. Untreated seed.
Plot 9. Soil check, etc.

The data in Table 17 are from an experiment in which the second planting arrangement was used. The variability in field stands of corn from untreated diseased seed that usually obtains, even in comparatively small experimental plots, is illustrated in Figure 11. The differences in the stands of the three rows, 14, 20, and 92, from untreated Diplodia-infected seed, were due largely to differences in soil moisture during the week following planting. The conditions responsible for the heavy development of seedling blight in row 92 and the subsequent reduction in stand, there being only one plant left, apparently did not have any detrimental effect on the growth of corn from good seed in the adjacent rows, 91 and 93.

The importance of using a soil check planted with treated nearly disease-free seed in experimental field plots, the object of which is to determine the comparative effectiveness of several seed disinfectants, is still further emphasized by the data presented in Table 18. In spite of the fact that each dust treatment was compared directly with an adjacent untreated 2-row plot (Table 18), and that these data represent the averages of eight replications, there is a difference of 5.5 bushels between the lowest and highest yielding set of eight replications planted with the same lot of untreated nearly disease-free seed. The range between the lowest and highest average yield of the different treatments is only 1.4 bushels. The average of the six sets of untreated plots is 57.3 bushels, with a standard deviation of 2.086. The average of the six sets of corresponding treatments is 59.5 bushels, with a standard deviation of 0.529. It is interesting to compare the increases in yield for the individual treatments with the difference in yield between each set of untreated plots and the average yield of the six treatments, 59.5. It will be observed that the size of the increases in yield for the different treatments is directly

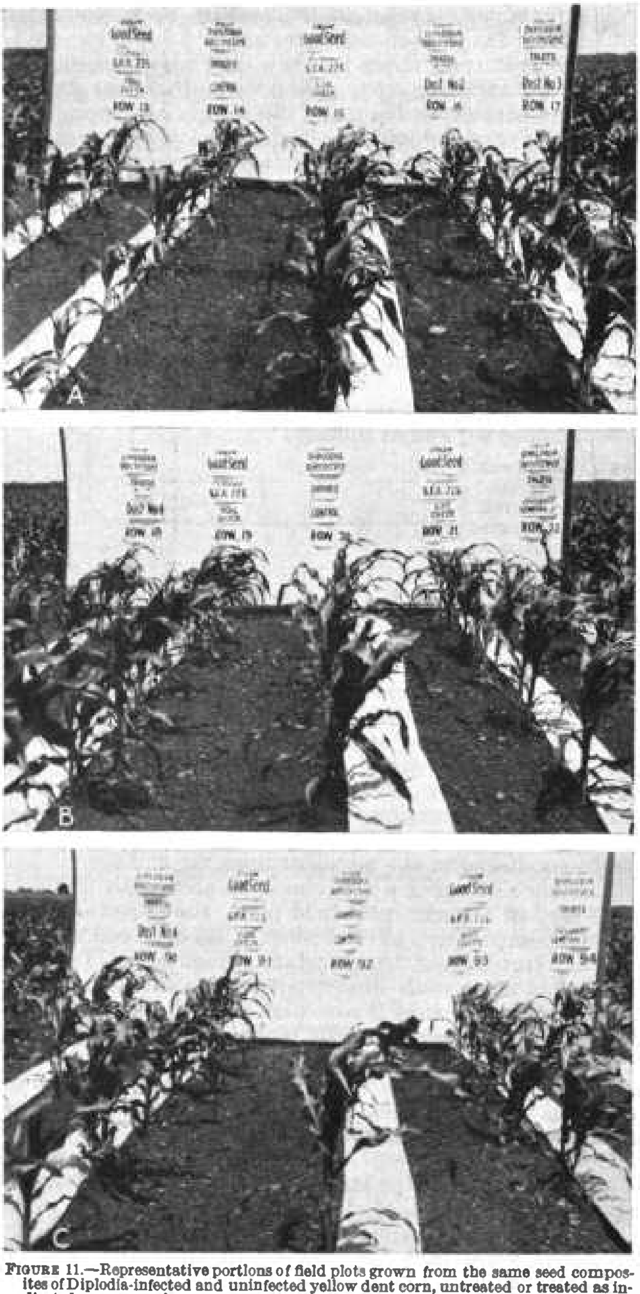


FIGURE 11.—Representative portions of field plots grown from the same seed composites of Diplodia-infected and uninfected yellow dent corn, untreated or treated as indicated, grown on the same type of soil near Bloomington, Ill., in 1927, showing differences in stand from the untreated Diplodia-infected seed (rows 14, 20, and 92) due largely to differences in soil moisture following planting. A and B had relatively low soil moisture, and C had relatively high soil moisture following planting

proportional to the extent which the yield of each set of untreated plots falls below the productive capacity of the field, approximately 60 bushels. Taking the data as they are in Table 18, dusts 2 and 6 are outstandingly better than any of the other dusts, as judged by the increases in yield following their use. They were the only dusts producing a statistically significant increase in yield. However, in other experiments in which the yields of the untreated plots were corrected on the basis of their average yield in relation to the yield of the soil checks planted with treated nearly disease-free seed in the same series of plots, the results were very different.

TABLE 18.—*Acre yields*[1] *of yellow dent corn from nearly disease-free seed, untreated and treated with six dust disinfectants, central Illinois, 1927*

Dust disinfectant	Acre yield from seed—		Increase in yield following treatment	Difference between average yield of all treated plots (59.5 bushels) and each set of untreated plots
	Untreated	Treated		
	Bushels	*Bushels*	*Bushels*	*Bushels*
No. 1	57.3	59.3	2.0	2.2
No. 2	54.6	58.9	[2] 4.3	4.9
No. 3	58.5	60.3	1.8	1.0
No. 4	[3] 60.1	60.2	.1	[3] .6
No. 5	58.8	59.3	.5	.7
No. 6	54.6	59.2	[3] 4.6	4.9
Average	57.3	59.5		
Standard deviation	2.086	.529		

[1] Average of 8 replications.
[2] Odds more than 30 to 1.
[3] An increase of 0.6 bushel over average yield of 59.5 bushels.

In this particular experimental plot much of the soil heterogeneity was due to disease factors controllable by seed treatment and not to differences in potential soil productivity. A larger number of replications and repetitions over a period of years would not necessarily overcome errors of this nature, due to the lack of an adequate soil check, in results from experiments the object of which is a comparison of the usefulness of a number of seed-treatment compounds.

The great majority of the plots were planted by hand, precautions being taken to prevent any of the dust disinfectants coming in contact with the untreated seed and also to avoid any mixing of the disinfectants. The corn was not thinned to a uniform stand. One of the benefits that may follow the use of satisfactory seed treatments, from the standpoint of commercial practice, is the improved field stands that frequently are secured from treated seed. Accompanying the increase in stand, or occurring independently, there may be a marked improvement in the vegetative vigor and general appearance of the corn from treated seed.

Yields were separated into marketable and unmarketable grades and reduced to a uniform moisture basis.

LOCATION OF FIELD EXPERIMENTS

In addition to the large experimental field plots at Bloomington and Urbana, many plots were conducted at widely separated points

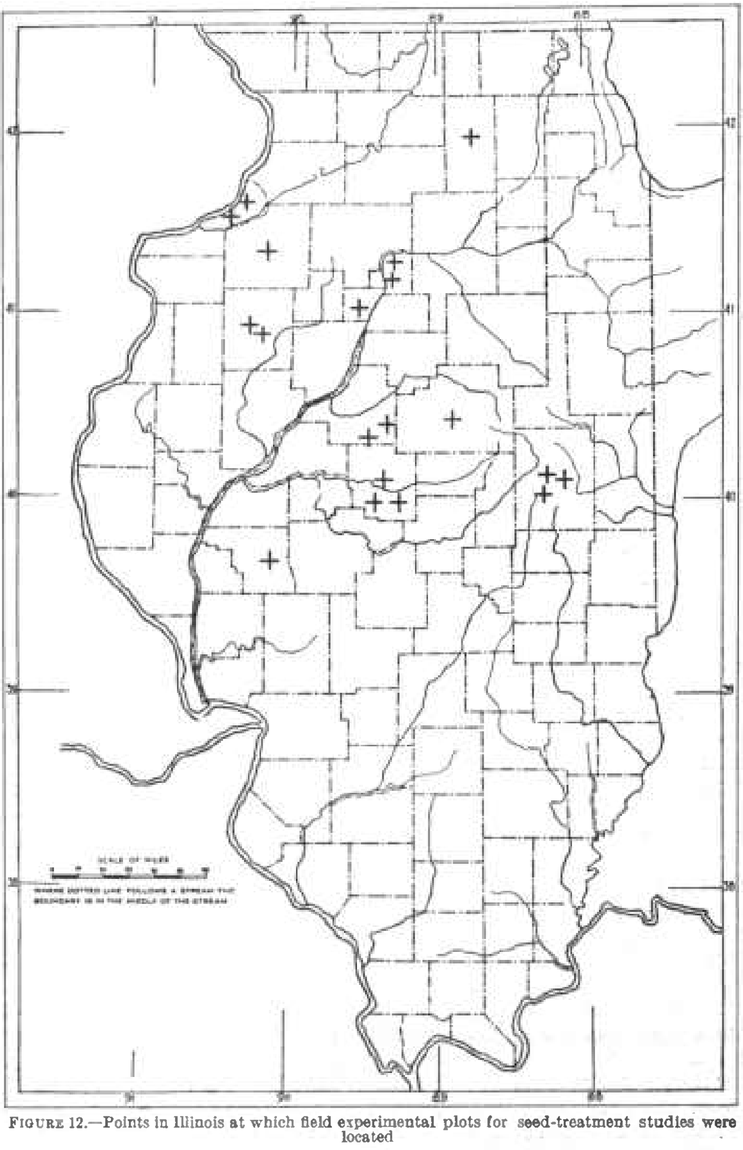


FIGURE 12.—Points in Illinois at which field experimental plots for seed-treatment studies were located

in Illinois, as indicated in Figure 12. Although each individual field experiment was located on as uniform soil as was available, an effort was made to use soils varying widely in productivity and previous cropping.

EXPERIMENTAL DATA AND DISCUSSION

PROBLEMS ENCOUNTERED IN SELECTING SATISFACTORY CORN-SEED DISINFECTANTS

A discussion of some of the difficulties encountered in determining the value of many corn-seed disinfectants furnishes a basis for the interpretation of the data presented later. Such a discussion also gives background for an appreciation of the qualifications that a corn-seed disinfectant should possess.

LABORATORY, GREENHOUSE, AND FIELD STUDIES ALL ESSENTIAL

Preliminary greenhouse and laboratory experiments are indispensable for the rapid elimination of numerous compounds and concentrations that obviously could have only doubtful value as corn-seed disinfectants. And, more important, greenhouse and laboratory studies are invaluable for the selections of compounds, and the approximate concentrations of such compounds, sufficiently promising to be included in field experiments. To conduct adequate field experimentation on any individual compound requires several experimental field plots representing different soil types and wide variations in soil moisture, soil temperature, and soil productivity. On this account only those compounds which in greenhouse and laboratory studies show evidence of possessing some of the necessary qualifications of corn-seed disinfectants were used in the more extensive field experiments.

Copper carbonate and many compounds useful in the control of vegetable and fruit diseases have not been found effective in reducing the seedling diseases of corn. Copper carbonate (Table 19) did not reduce Diplodia seedling blight in the greenhouse and reduced it only slightly in the field. On the other hand, mercurized acetaldehyde typical of many other compounds in its effect on corn, gave partial control of Diplodia seedling blight in the greenhouse, with an increase in yield of 8.5 bushels in the field.

TABLE 19.—*Comparison of data from experiments conducted in the greenhouse and in the field on a number of seed-treatment compounds, using nearly disease-free seed, Diplodia-infected seed, and Gibberella-infected seed, central Illinois, 1925 and 1926*

Form of seed-treatment compound	Toxic ingredient	Data from greenhouse experiments with untreated and treated Diplodia-infected seed		Increase (+) or decrease (−) in acre yield following seed treatment		
		Green weight of tops	Plants with mesocotyls showing no rotting	Nearly disease-free seed	Diplodia-infected seed	Gibberella-infected seed
		Grams	*Per cent*	*Bushels*	*Bushels*	*Bushels*
Dust	Copper carbonate	7.6	0	----------	+1.0	----------
Do	Mercurized acetaldehyde	19.1	59.6	----------	+8.5	----------
Liquid	Hydroxymercuriorthochlorophenol	25.7	90.8	+1.9	+18.1	+5.3
Do	Hydroxymercuriorthonitrophenol	27.8	90.9	−2.1	+19.3	+7.0
Do	Copper salt in miscible oil	23.3	46.9	+.5	+13.1	+7.3
Dust	Hydroxymercuriparanitrophenol	23.1	81.0	−3.7	+10.7	+16.6
Do	Hydroxymercuriorthonitrophenol	24.1	69.7	+8.8	+15.8	----------
Liquid	Acetoxymercuriorthonitrophenol	25.2	90.3	−10.6	+7.4	----------
Dust	Hydroxymercuricresol	22.2	73.5	+2.6	+9.6	----------
Do	Hydroxymercurichlorophenol	22.9	74.0	−.3	+9.3	----------
Liquid	do	24.5	89.5	−1.7	+6.3	+8.9
Dust	Cyanmercuricresol	23.2	84.0	+.8	+10.5	+4.9

Other compounds gave better disease control in the greenhouse than mercurized acetaldehyde, and their use resulted in greater increases in the yield of corn from Diplodia-infected seed. Indispensable as they are, however, there seems to be a limit to the extent to which favorable laboratory and greenhouse results from the use of any corn-seed disinfectant can be used as an indication of favorable results that are likely to follow the extensive use of the same seed disinfectant in the field. For example, hydroxymercuriorthochlorophenol and hydroxymercuriorthonitrophenol (Table 19) each produced a very high degree of disease control in the greenhouse, the latter being somewhat better from the standpoint of weight of tops. But, used in the field on good seed, the former gave an increase of 1.9 bushels in yield and the latter a decrease of 2.1 bushels that was statistically significant.

Again, compounds that give apparently almost perfect disease control under greenhouse conditions, and with no perceptibly depressing effects on the growth of corn from good seed under the same conditions, may be disappointing under some conditions when used in field experimental plots. Hydroxymercuriparanitrophenol gave much better disease control in the greenhouse than the copper salt (Table 19), 81.0 per cent of clean mesocotyls from the use of the former as compared with only 46.9 per cent from the latter. In the field, however, the copper salt gave better results on both good seed and Diplodia-infected seed. Contrast in the results from greenhouse and field study is even greater in the comparison of hydroxymercuriorthonitrophenol and acetoxymercuriorthonitrophenol in Table 19. The latter produced very favorable results in the greenhouse, but its use on good seed in the field was followed by a decrease in yield of 10.6 bushels.

In many preliminary greenhouse experiments hydroxymercuricresol and hydroxymercurichlorophenol as dusts gave very similar results. (Table 19.) But the former dust consistently produced a more satisfactory effect than the latter on the yield of corn from good seed in field experiments.

Under some greenhouse conditions, liquid treatment with hydroxymercurichlorophenol gave slightly better indications than cyanmercuricresol as a dust. Such results are usually reversed in field experiments. (Table 19.)

Up to the present time it has been the experience of the writers that the compounds and concentrations of those compounds which were the most effective in disease control under greenhouse and laboratory conditions seldom give the most favorable results in the field. Compounds that are sufficiently toxic to give complete disease control frequently have a depressing effect on the yield of corn from good seed. On the other hand, those compounds having little fungicidal value under greenhouse and laboratory conditions and those inhibiting growth under greenhouse and laboratory conditions do not need further trial in the field to justify their elimination.

Seed lots that are used for planting in the Corn Belt usually contain a mixture of good seed and diseased seed. The nature of the infection varies greatly in different seed lots, from season to season, and in different localities. It is highly important, therefore, for a satisfactory corn-seed disinfectant to have the best disease-control qualities possible without combining with such qualities undesirable properties that cause depressing effects on the growth of corn from the good seed in the same seed lot. The knowledge of a proper balancing of all the ingredients in any satisfactory corn-seed disinfectant, in order to secure these beneficial results from seed treatment, can be obtained only by extended study both in the laboratory and in the field.

There is great need for standardized laboratory methods for quick and accurate determination of the efficiency of new seed-treatment compounds as they appear on the market, but, up to the present time, the writers have not found any reliable short cut that can replace field experiments conducted under a wide range of environmental conditions with different strains of corn.

SEED DISINFECTANTS NOT EQUALLY EFFECTIVE IN CONTROLLING ALL DISEASES

A corn-seed disinfectant may be very effective in controlling one seed-borne disease and at the same time be relatively ineffective in the control of some other equally important seed-borne disease. Basic mercuric acetate has controlled Diplodia seedling blight equally as well as has hydroxymercurichlorophenol. (Table 20.) The use of the former gave an increase in yield of 10.9 bushels, and the latter 10.3 bushels. Basic mercuric acetate, however, gave only a slight increase in yield when used on Gibberella-infected seed. Hydroxymercurichlorophenol gave an increase of 11.2 bushels.

TABLE 20.—*Comparison of efficacy of some seed-treatment compounds in controlling each of two or more seed-borne diseases, central Illinois, 1924, 1926, and 1927*

Form of seed-treatment compound	Toxic ingredient	Kind of diseased seed used	Increase [1] in acre yield following treatment
			Bushels
Dust	Basic mercuric acetate	Diplodia-infected	10.9
		Gibberella-infected	[2] .7
Liquid	Hydroxymercurichlorophenol	Diplodia-infected	10.3
		Gibberella-infected	11.2
Dust	Hydroxymercurinitrophenol	Diplodia-infected	9.9
		Gibberella-infected	[2] .3
Liquid	Hydroxymercurichlorophenol	Diplodia-infected	6.3
		Gibberella-infected	8.9
Dust	do	Diplodia-infected	14.3
		Miscellaneously infected	[2] .2
Do	Hydroxymercuricresol	Diplodia-infected	16.9
		Miscellaneously infected	8.6

[1] Average of 8 paired comparisons.
[2] Odds less than 30 to 1; all others greater than 30 to 1.

Again, hydroxymercurinitrophenol gave an increase of 9.9 bushels, as compared with 6.3 bushels from hydroxymercurichlorophenol, when used on Diplodia-infected seed. (Table 20.) But hydroxymercurinitrophenol, in this experimental plot, was not effective in controlling Gibberella seedling blight.

Hydroxymercurichlorophenol, prepared for use as a dust, increased the yield of Diplodia-infected seed 14.3 bushels (Table 20) and was effective in reducing injury from Gibberella seedling blight under the conditions represented in this experiment. But this dust disinfectant gave only a slight increase in yield on seed slightly infected with a number of miscellaneous organisms, as compared with an increase of 8.6 bushels following the use of hydroxymercuricresol.

A seed-treatment compound capable of controlling only one seedling-blight disease was found to give widely differing results on different seed lots and in different localities. In order for a corn-seed treatment compound to give consistently beneficial results it is very necessary for that compound to have a wide range of toxicity and to be reasonably effective in the control of all the more important seed-borne diseases and at the same time to cause a minimum amount of injury to good seed.

SOME TREATMENTS CONTROL DIPLODIA SEEDLING BLIGHT BUT ARE HARMFUL TO GOOD SEED

A few seed disinfectants were used to which there appeared to be no objection from the standpoint of enabling corn grown from Diplodia-infected seed to make a maximum yield, but which caused statistically significant reductions in the yield of corn from good seed. Mercuric thiocyanate, used as a seed disinfectant on Diplodia-infected seed, gave as large an increase in yield as could be expected, the treated Diplodia-infected seed yielding 73.6 bushels as compared with 74.9 bushels from untreated nearly disease-free seed. (Table 21.) This same treatment on good seed, however, was followed by a decrease in yield of 9.3 bushels, with odds of 587 to 1. Corn grown from Diplodia-infected seed treated with a dust containing a mixture of hydroxymercurichlorophenol and hydroxymercuricuprinitrophenol yielded a little more than good seed untreated, 40.1 bushels compared with 38.3 bushels. (Table 21.) But corn grown from good seed treated with this dust yielded 4.3 bushels less than corn from untreated seed. Similar beneficial effects on the yield of corn from Diplodia-infected seed and depressing effects on the yield of corn from good seed were obtained with mercuric chloride and the dust containing a mixture of hydroxymercurichlorophenol and hydroxymercurinitrophenol. Corn from diseased seed frequently has been observed to be more resistant to injury from certain seed disinfectants than has corn from good seed. No explanation for this is offered.

TABLE 21.—*Data showing the depressing effect on the yield of corn from good seed of some seed treatments that were effective in controlling Diplodia seedling blight, central Illinois, 1925, 1926, and 1927*

Form of seed-treatment compound	Toxic ingredient	Acre yield from Diplodia-infected seed		Acre yield from untreated nearly disease-free seed	Reduction in acre yield following treatment of nearly disease-free seed	
		Untreated	Treated			
		Bushels	*Bushels*	*Bushels*	*Bushels*	*Odds*
Liquid	Mercuric thiocyanate	58.7	73.6	74.9	9.3	587:1
Dust	Mixture of hydroxymercurichlorophenol and hydroxymercuricuprinitrophenol.	31.3	40.1	38.3	4.3	24:1
Do	Mercuric choloride	33.0	39.8	40.3	5.1	32:1
Do	Mixture of hydroxymercurichlorophenol and hydroxymercurinitrophenol.	32.0	53.4	55.4	5.1	100:1

Results similar to those reported in Table 21 probably would not always be obtained from the use of these compounds or those having such properties. But the fact that such compounds may have a depressing effect on the yield of corn from good seed is sufficient cause to disqualify them for general use until the property causing the depressing effect on the yield of corn from good seed can be overcome by a modification of the formula under which the compound is manufactured.

EXTENT OF INJURY FROM UNSATISFACTORY SEED DISINFECTANTS VARIES UNDER DIFFERENT ENVIRONMENTS

Some seed disinfectants, particularly those prepared for use as dusts, may give significant increases in the yield of corn from good seed under one environment and cause marked depressions in the yield of corn from the same lot of good seed under other environments. In Illinois a dust whose toxic ingredient was a mixture of mercurous chloride and mercuric chloride gave an increase in yield of 2.8 bushels at De Kalb and a decrease of 9.0 bushels in an experimental plot at Bloomington. (Table 22.) Hydroxymercuriparanitrophenol gave an increase of 3.1 bushels at Bloomington and a decrease of 3.7 bushels at Urbana. The use of mercuric chloride resulted in a decrease in yield at both Bondville and Urbana, but the decrease was much greater at the former place, 2.9 bushels as compared with 0.8 bushel. The dust containing a mixture of hydroxymercurichlorophenol and hydroxymercurinitrophenol gave decreases at both Urbana and Bloomington. (Table 22.) At Urbana the decrease was only slight, but at Bloomington the decrease was 5.1 bushels. Mercuric amino chloride gave an increase of 5.3 bushels at Hillsdale and a decrease of 4.6 bushels at McNabb. Hydroxymercurinitrophenol may give marked control of Gibberella seedling blight under one environment and very little control under another environment. (Table 22.)

TABLE 22.—*Comparison of effects following the use of some seed-treatment compounds used as dust disinfectants where corn was grown from the same lots of treated and untreated seed at different places in central Illinois, 1925–1927*

Toxic ingredient in seed-treatment compound	Kind of seed	Location in Illinois	Increase or decrease in acre yield following seed treatment			
			Increase	Odds	Decrease	Odds
			Bushels		*Bushels*	
Mixture of mercurous chloride and mercuric chloride.	Good	De Kalb	2.8	18:1		
		Bloomington			9.0	547:1
Hydroxymercuriparanitrophenol	do	do	3.1	35:1		
		Urbana			3.7	40:1
Mercuric chloride	do	Bondville			2.9	50:1
		Urbana			.8	1:1
Mixture of hydroxymercurinitrophenol and hydroxymercurichlorophenol.	do	do			.5	1:1
		Bloomington			5.1	100:1
Mercuric amino chloride	do	Hillsdale	5.3	8:1		
		McNabb			4.6	80:1
Hydroxymercurinitrophenol	Gibberella-infected.	Bloomington	14.7	>9,999:1		
		Lincoln	3.1	3:1		

The above data emphasize the importance of locating experimental plots at a number of places. Experimental dust disinfectants whose use has been followed by beneficial results in one locality and adverse results in other localities were not included in further field experiments excepting in cases in which a modification of the formula appeared to offer improvement. Furthermore, these data point out the necessity for a dust disinfectant to be so constituted that there is a minimum fluctuation in fungicidal properties under any set of soil conditions and also so that there is a constant minimum of seed injury.

It seems evident from the data presented in Table 22 that the general usefulness of any seed disinfectant can not be based on the results from comparatively few experiments under one set of conditions.

GENERAL GROUPING OF CORN-SEED DISINFECTANTS BASED ON DISEASE CONTROL AND SEED INJURY

On the basis of the behavior of corn from treated seed in experimental field plots, the great majority of the seed-disinfectant compounds and concentrations of those compounds included in the field experiments conducted by the writers may be classified as follows:

Class A.—Compounds giving almost full disease control and no seed injury.

Class B.—Compounds giving partial to good disease control and no apparent seed injury.

Class C.—Compounds giving partial to good disease control and seed injury, the seed injury being measured by the decrease in the yield of corn from good seed treated with these same seed-treatment compounds.

Data on seed injury following the use of compounds falling into class C are presented in Table 23 and Figure 13. On Diplodia-infected seed and on Gibberella-infected seed, the class C seed disinfectants gave marked increases in yield, ranging from 13.0 to 17.2 bushels, with significant odds. But in both series 2 and 3,[5] Table 23, the use of the class C compounds on good seed resulted in significant decreases in yield, 5.4 bushels, with odds of 90 to 1, and 3.6 bushels, with odds of 4,999 to 1. The use of the class A compounds was followed by larger increases in yield from both Diplodia and Gibberella infected seed, and there were slight increases in the yield of good seed treated with the class A seed-treatment compounds. (Table 23.)

TABLE 23.—*Acre yields of yellow dent corn from nearly disease-free seed, from Diplodia-infected seed, from Gibberella-infected seed, and from Basisporium-infected seed, each untreated and treated with three classes of seed disinfectants, Bloomington, Ill., 1926 and 1927*

Series and seed-disinfectant class	Kind of seed	Replications	Acre yield from seed— Untreated	Acre yield from seed— Treated	Increase or decrease in yield following seed treatment: Increase	Decrease	Odds
		Number	*Bushels*	*Bushels*	*Bushels*	*Bushels*	
Series 1:							
A	Nearly disease-free	16	60.2	61.3	1.1		17:1
	Diplodia-infected	16	43.1	54.3	11.2		>9,999:1
B	Nearly disease-free	16	60.4	60.1		0.3	10:1
	Diplodia-infected	16	43.7	50.9	7.2		>9,999:1
Series 2:							
A	Nearly disease-free	12	60.4	61.1	.7		5:1
	Diplodia-infected	12	38.0	55.8	17.8		>9,999:1
	Basisporium-infected	12	55.4	59.7	4.3		73:1
C	Nearly disease-free	12	59.7	54.3		5.4	90:1
	Diplodia-infected	12	37.2	50.2	13.0		7,999:1
	Basisporium-infected	12	55.2	56.4	1.2		2:1
Series 3:							
A	Nearly disease-free	24	54.4	55.0	.6		1:1
	Diplodia-infected	24	32.9	54.2	21.3		>9,999:1
	Gibberella-infected	24	37.3	55.5	18.2		>9,999:1
B	Nearly disease-free	8	56.0	55.7		.3	9:1
	Diplodia-infected	8	34.5	51.9	17.4		>9,999:1
	Gibberella-infected	8	37.3	53.1	15.8		898:1
C	Nearly disease-free	24	55.5	51.9		3.6	4,999:1
	Diplodia-infected	24	32.4	49.6	17.2		>9,999:1
	Gibberella-infected	24	38.5	53.4	14.9		>9,999:1

[5] The series numbers here and in the following text and tables refer to different series of experiments.

The increase in the yield of the Diplodia-infected seed treated with the class A disinfectants over that treated with the class C disinfectants (the difference between 17.8 bushels and 13.0 bushels, or 4.8 bushels, series 2, Table 23) is within 0.6 bushel of being the same as the decrease in the yield of corn from good seed treated with the class C disinfectants, 5.4 bushels. The amount of the decrease in yield of nearly disease-free seed following treatment with the class C disinfectants, 5.4 bushels, might be called the factor of seed injury, equivalent, in some respects, to "therapeutic index" used in medicine, i. e., the ratio of the toxic dose to the therapeutic dose. In series 3 the factor of seed injury, 3.6 bushels, can be compared with the difference between the 21.3 bushels increase from Diplodia-infected seed with the class A treatments and the 17.2 bushels increase from Diplodia-infected seed with class C treatments, or 4.1 bushels. The difference between the increase of 18.2 bushels from Gibberella-infected seed treated with class A disinfectants and 14.9 bushels when treated with class C disinfectants, or 3.3 bushels, has a similar relationship to this factor.

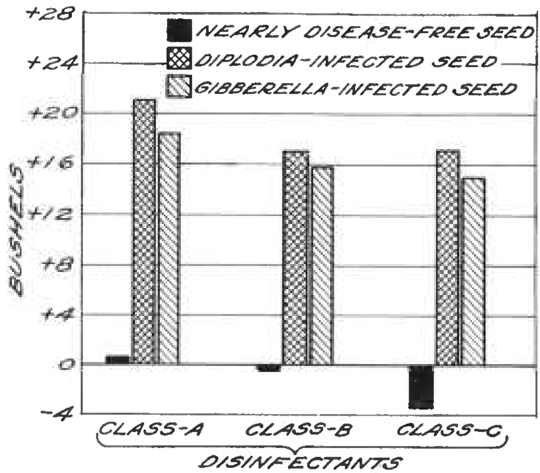


FIGURE 13.—Increases and decreases in yield from nearly disease-free, Diplodia-infected, and Gibberella-infected seed, following the use of class A, class B, and class C disinfectants, respectively. (Data in series 3, Table 23)

Some seed disinfectants which apparently cause no seed injury do not have sufficient fungicidal value to effect disease control. These, class B disinfectants, gave an increase in the yield of Diplodia-infected seed of only 7.2 bushels, as compared with an increase of 11.2 bushels following treatment with the disinfectants in class A, series 1. (Table 23.) To give consistently beneficial results on many different varieties and selections of corn, seed-treatment compounds should possess the highest possible fungicidal properties that can be obtained without injury to the seed.

DUST TREATMENTS BETTER THAN SOAK TREATMENTS

Although the liquid treatment with hydroxymercurichlorophenol, soaking the seeds for one and one-half hours in 0.5 per cent solution at 30° C., which is one of the best liquid treatments, gives consistently beneficial results on diseased seed, the results from this same liquid treatment on good seed are not always satisfactory. The data on which the decision to discontinue experimentation on all liquid treatments was based are presented in Table 24. At Urbana, hydroxymercurinitrophenol, used as a dust on good seed, gave an increase in yield of 2.6 bushels over the yield of seed from the same seed lot that had been given a liquid treatment. At Bloomington the margin in favor of dust treatment with hydroxymercuricresol over the liquid treatment was 4.3 bushels. This same dust disinfectant gave a higher increase in the yield of corn from treated Diplodia-infected seed than did the soak treatment on the same lots of Diplodia-infected seed.

TABLE 24.—*Increase in acre yield of yellow dent corn from the use of dust treatments over liquid treatments (hydroxymercurichlorophenol) on good seed and on Diplodia-infected seed, Urbana and Bloomington, Ill., 1926*

Location of experiments	Toxic ingredient of dust disinfectant	Kind of seed	Total plots	Increase in yield of dust-treated seed over liquid-treated seed	
			Number	*Bushels*	*Odds*
Urbana	Hydroxymercurinitrophenol	Good	128	2.6	>9,999:1
Bloomington	Hydroxymercuricresol	do	18	4.3	41:1
Do	do	Diplodia-infected	34	2.4	10:1

The advantage of the dust treatments over the soak treatments may be accounted for, in part, by the fact that soaking followed by drying before planting has proved to be injurious at times, and very likely because dust treatments offer better protection against infection from soil-borne organisms. In addition to giving greater yield increases, especially on good seed, the dust disinfectants can be applied more economically, and during the spring this can be done well in advance of planting when other work is not pressing.

EFFECTS OF SEED TREATMENTS

EFFECTS ON FIELD STAND

Treated seed usually produces a better field stand from the same quantity of seed than untreated seed. The extent to which the field stand may be benefited by seed treatment depends on such factors as quality of seed, infection of seed (fig. 14), weather conditions following planting, infection of soil, and the disease resistance of the strain of corn. Corn from treated nearly disease-free seed has almost always given a slightly higher field stand than the untreated seed. The increases in field stand from the best quality seed were small in 1927 and 1928, averaging 2.7 per cent and 1.7 per cent, respectively. (Table 25.) These increases, however, were statistically significant.

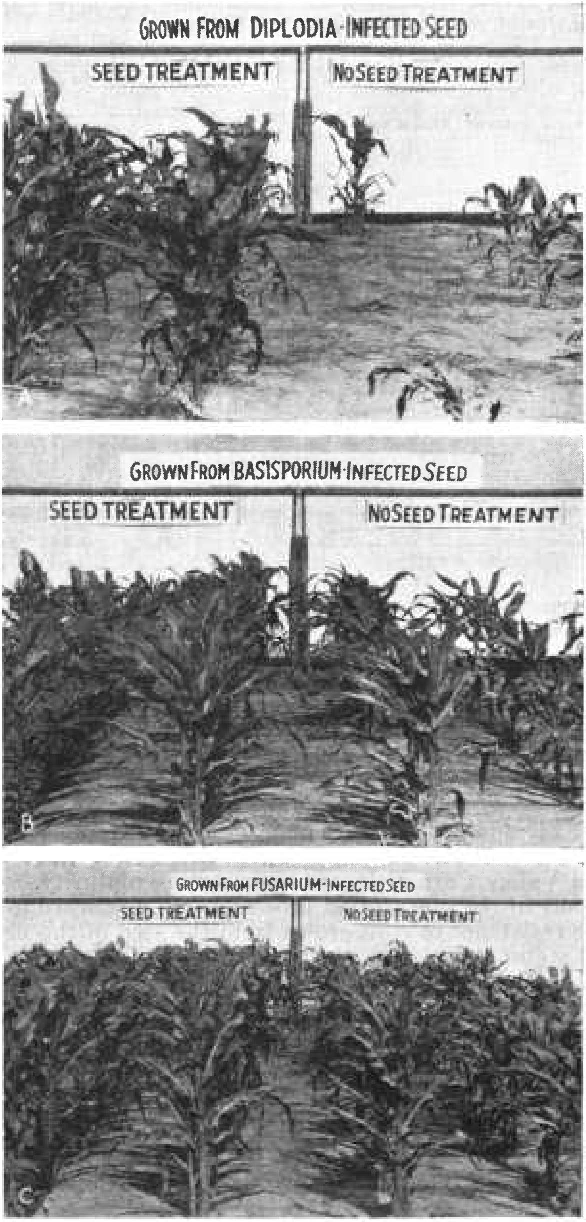


FIGURE 14.—Corn grown from treated and untreated (A), Diplodia-infected; (B), Basisporium-infected; and (C), Fusarium-infected seed composites

TABLE 25.—*Field stand of yellow dent corn from nearly disease-free seed and from seed primarily infected with Diplodia, Gibberella, Basisporium, Fusarium, and Cephalosporium, respectively, and scutellum-rot susceptible seed, each untreated and treated, central Illinois, 1927–1929*

Year of experiments and kind of seed	Experiments	Field stand from seed—		Percentage rate of increase following seed treatment	Odds
		Untreated	Treated		
1927	*Number*	*Per cent*	*Per cent*	*Per cent*	
Nearly disease-free	23	88.3	90.7	2.7	199:1
Diplodia-infected	22	55.7	78.6	41.1	>9,999:1
Gibberella-infected	14	69.1	85.8	24.2	>9,999:1
Basisporium-infected	14	83.6	86.7	3.7	68:1
Fusarium-infected	13	85.1	87.9	3.3	932:1
Cephalosporium-infected	12	87.3	87.9	.7	4:1
Scutellum-rot susceptible	6	83.2	86.1	3.5	3,399:1
1928					
Nearly disease-free	9	88.5	90.0	1.7	539:1
Diplodia-infected	6	57.2	77.1	34.8	>9,999:1
Gibberella-infected	3	64.7	82.2	27.0	88:1
Basisporium-infected	3	81.6	84.3	3.3	5:1
1929					
Nearly disease-free	5	70.1	75.4	7.6	128:1
Diplodia-infected	10	39.3	58.4	48.6	4,999:1
Gibberella-infected	5	56.1	68.0	21.2	199:1
Basisporium-infected	9	62.7	66.3	5.7	999:1
Scutellum-rot susceptible	6	61.9	68.3	10.3	46:1

The increase in the field stand of nearly disease-free seed following seed treatment in 1929 was 7.6 per cent, with odds of 128 to 1, a much higher figure than the average increases in the two former years. The field stand from the untreated seed in 1929 was markedly lower than the field stands from the untreated nearly disease-free seed in former years, 70.1 as compared with 88.3 and 88.5 per cent, due principally to the poorer quality of the seed used in 1929, which probably was caused by the unseasonably cold weather that prevailed in many sections of the Corn Belt during the nights of September 23, 24, and 25, 1928. These unfavorably cold temperatures during the last week in September, at which time corn in the upper Mississippi Valley Corn Belt was approaching maturity, resulted in a retardation in the maturation processes and a marked lowering in the disease resistance of corn grown from the seed of this crop. The benefits in stand and also in yield from the use of seed treatment on this class of seed has particular interest and significance.

Field stands of corn from well-selected but untested seed may be greatly benefited by seed treatment, if weather conditions following planting are favorable for disease development in the seedling stage. In the experimental field plots, results from which are presented in Table 11, the soil was cold and wet for about three weeks following planting. The increases in stand of 5.7 and 12.9 per cent, with odds of 171 to 1 and greater than 9,999 to 1, are very marked. There also was a slight increase in plant yield in the treated plots. (Table 11.)

Data presented in Table 25 are summarized in Table 26 and presented graphically in Figure 15. In all instances the field stands were substantially improved by seed treatment. The stand of corn from Diplodia-infected seed was increased 40.8 per cent, and that from Gibberella-infected seed was increased 24.3 per cent. The stand from Basisporium-infected seed was increased 4.1 per cent, and from scutellum-rot susceptible seed 6.3 per cent. The stand from Fusarium-infected seed was increased 3.3 per cent by seed

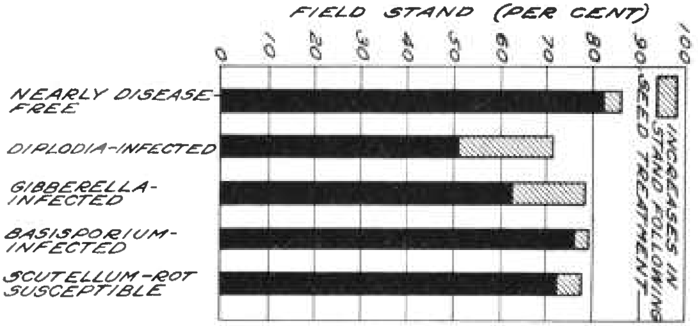


FIGURE 15.—Field stands from untreated and treated seed. (Data from Table 26)

treatment. But the stand from Cephalosporium-infected seed was not benefited appreciably by seed treatment.

TABLE 26.—*Summary of data presented in Table 25*

Kind of seed	Field stand from seed—		Percentage rate of increase following seed treatment
	Untreated	Treated	
	Per cent	*Per cent*	*Per cent*
Nearly disease-free	82.3	85.4	3.8
Diplodia-infected	50.7	71.4	40.8
Gibberella-infected	63.3	78.7	24.3
Basisporium-infected	76.0	79.1	4.1
Scutellum-rot susceptible	72.6	77.2	6.3

EFFECTS ON VEGETATIVE VIGOR AND PLANT YIELD

In addition to increasing field stand, seed treatment with satisfactory dust disinfectants frequently produces an increase in the percentage of strong, vigorous plants. (Table 27.) In 1929 the junior writer made plant-height measurements in a large number of field plots on the University of Illinois agronomy farm. These data are presented in Table 28. The averages show a consistent increase in height following the use of a seed disinfectant. Five of the seven height increases are statistically significant. The increases in plant height, as well as the increases in field stand, in corn grown from average farm seed are illustrated in Figures 14 and 16.

FIGURE 16.—Corn grown from treated and untreated average farmers' seed, University of Illinois agronomy farm, Urbana, Ill., 1929

TABLE 27.—*Increase in percentage of kernels producing strong vigorous plants following seed treatment, in yellow dent corn from nearly disease-free seed and from diseased seed*

Kind of seed	Experiments	Increase in kernels producing strong vigorous plants	Odds
	Number	*Per cent*	
Nearly disease-free	10	4.7	44:1
Diseased	17	31.1	>9,999:1

TABLE 28.—*Mean height of plants of yellow dent corn from untreated seed and from treated seed; corn planted May 4 and measured June 29, 1929, University of Illinois agronomy farm, Urbana, Ill.*

Kind of seed	Plots whose plant populations were measured	Mean plant height in plots from seed—		Increase in plant height following seed treatment	Odds
		Untreated	Treated		
	Number	*Inches*	*Inches*	*Per cent*	
Nearly disease-free	8	41.5	43.0	3.6	48:1
Diplodia-infected	4	29.4	34.6	17.7	77:1
Basisporium-infected	4	30.7	32.3	5.2	45:1
Fusarium-infected	4	34.9	35.8	2.6	87:1
Cephalosporium-infected	4	34.8	35.7	2.6	10:1
Scutellum-rot susceptible	4	31.9	34.4	7.8	15:1
Average farm corn	8	42.5	43.7	2.8	42:1

Sometimes where no increase in actual stand follows seed treatment there may be a marked improvement in the tone and quality of the plants. In general, there are three types of beneficial effects that class A (Table 23) seed disinfectants may produce on corn from well-selected seed. (Table 29.) (1) The stand may be increased only slightly, but the mean plant yield may be increased significantly.

(2) There may be a marked increase in stand and a slight decrease in mean plant yield, due to lack of moisture and plant nutrients on account of the greatly increased stand, but, nevertheless, an accompanying increase in acre yield. (3) Both stand and plant yield may be increased significantly.

TABLE 29.—*Three type effects on percentage of field stand and plant yield of yellow dent corn following seed treatment of nearly disease-free seed with class A (Table 23) seed disinfectants, planted early in May near Bloomington, Ill., 1927 and 1928*

Field stand from untreated seed	Increase in field stand following seed treatment		Increase (+) or decrease (−) in plant yield following seed treatment	
Per cent	*Per cent*	*Odds*	*Per cent*	*Odds*
90	+1.6	3:1	+8.2	>9,999:1
87	+10.0	>9,999:1	−3.0	1,428:1
87	+7.5	413:1	+9.1	416:1

EFFECTS ON SOIL-BORNE DISEASES

A part of the increase in stand of corn from the nearly disease-free seed (Tables 25, 26, and 29) and from the well-selected but untested seed (Table 11) can be attributed to the slight infections by Diplodia and Gibberella that were not eliminated from the seed lots. The well-selected seed also carried slight infections of a group of miscellaneous organisms, the control of which by seed treatment probably contributed materially to the increase in stand and to the better quality of the plants. It does not seem possible to account for the increases in stand and plant yield from the treated nearly disease-free seed reported in Table 29 entirely on the basis of the control of seed-borne disease-producing organisms. It seems more probable that the seed treatment may have had a protective action in preventing injury from soil-borne disease-producing organisms. This interpretation is strengthened by the consistently better results on good seed that were produced with dust disinfectants than were produced with the liquid treatments. (Table 24.) The latter treatments may have been equally effective, and in some instances more effective, in controlling seed-borne infections. But the dust disinfectants gave greater increases, statistically significant, on well-selected seed where seed-borne seedling blight-producing organisms were not the predominating factor in causing reductions in stand and in seedling vigor.

EFFECTS ON LODGING

Koehler, Dungan, and Holbert (*8*) presented data to show that corn from diseased seed usually had more leaning plants than corn from good seed of the same strain. In so far as lodging is caused by infections during the seedling stage, seed treatment might be expected to reduce it. Data on the percentage of lodged plants from untreated and from treated good and diseased seed are presented in Table 30. In series 1 and 3 the corn from treated seed had fewer leaning plants. Threo of these four figures are statistically significant, 13.9 per cent, with odds of 47 to 1, 13.8 per cent, with odds of 328 to 1, and 22 per cent, with odds of 888 to 1.

TABLE 30.—*Plants leaning 30° or more in populations of yellow dent corn grown from good seed, from diseased seed, and from average farmers' seed, each untreated and treated with a dust disinfectant, central Illinois, 1924–1928*

Series of experiments	Kind of seed	Experiments	Plants leaning 30° or more, grown from seed—		Increase (+) or decrease (−) in leaning plants following seed treatment	
			Untreated	Treated		
		Number	*Per cent*	*Per cent*	*Per cent*	*Odds*
1	Good	10	36.8	31.7	−13.9	47:1
	Diseased	17	49.2	42.4	−13.8	328:1
2	Good	16	74.5	76.3	+2.4	11:1
	Diseased	18	72.3	72.3		
3	Good	21	20.9	16.3	−22.0	888:1
	Diseased	24	19.5	18.8	−3.6	8:1
4	Average farmers' seed	19	32.9	33.9	+3.0	140:1

Many factors, however, are involved in determining the resistance or susceptibility of any population of corn plants to lodging. The experimental plots represented in series 2 were subjected to heavy rain and windstorms during September. The corn from treated good seed had a slightly higher percentage of lodged plants, 2.4 per cent, with odds of 11 to 1, than the corn from the same lots of seed untreated. Corn from untreated and from treated diseased-seed lots had the same percentage of lodged plants, 72.3.

In the corn from average farmers' seed there was an increase of 3 per cent in the lodging in the plots of corn from treated seed, although this corn yielded significantly more than that from the untreated seed.

The complexity of the factors determining the amount of lodging in any given population of corn plants is suggested by the data presented in Tables 31 and 32. In the rotation of corn, corn, spring grain, and clover, corn grown from treated seed had fewer leaning plants than corn from untreated seed. One of the four decreases was statistically significant, 46.3 per cent, with odds of 177 to 1. (Table 31.) But in the rotation of corn, corn, corn, and soybeans, corn from treated seed lodged more than corn from untreated seed in three of the four series, although neither the increases nor the decreases were statistically significant.

TABLE 31.—*Percentage* [1] *of plants leaning 30° or more in populations of yellow dent corn grown from diseased seed, seed untreated, and seed treated with a dust disinfectant; corn grown on two rotations on the University of Illinois agronomy farm, Urbana, Ill., planted May 4, 1929*

Rotation	Previous crop in rotation	System of farming	Plants leaning 30° or more from seed—		Increase (+) or decrease (−) in leaning plants following seed treatment	Odds
			Untreated	Treated		
			Per cent	*Per cent*	*Per cent*	
Corn, corn, spring grain, clover	Clover	Grain [2]	21.5	18.7	−13.0	5:1
		Livestock [2]	12.7	12.6	−.8	1:1
	Corn	Grain	39.3	21.1	−46.3	177:1
		Livestock	14.2	11.5	−19.0	7:1
Corn, corn, corn, soybeans	Soybeans	Grain	22.2	30.5	+37.4	6:1
		Livestock	9.9	11.9	+20.2	6:1
	Third-year corn	Grain	67.6	70.6	+4.6	9:1
		Livestock	38.6	33.8	−12.4	7:1

[1] Averages of 8 replications.
[2] In the grain system all the grain is removed and the crop refuse is returned to the soil; in the livestock system both grain and crop refuse are removed and manure equivalent in amount to the crop refuse is applied to the soil.

TABLE 32.—*Percentages*[1] *of plants leaning 30° or more in populations of two varieties of yellow dent corn grown in a rotation of corn, corn, spring grains, and clover, seed untreated and seed treated, planted respectively, May 1, May 11, May 21, and May 31, 1929, at the University of Illinois agronomy farm, Urbana, Ill.*

Date of planting	Previous crop in a rotation of corn, corn, spring grains, clover	Strain of corn	Plants leaning 30° or more from seed— Untreated	Plants leaning 30° or more from seed— Treated	Increase (+) or decrease (−) in leaning plants following seed treatment	Odds
			Per cent	*Per cent*	*Per cent*	
May 1	Clover	[2] A	6.4	4.7	−26.6	46:1
		[3] B	13.9	9.7	−30.2	30:1
	Corn	A	12.4	9.8	−21.0	22:1
		B	14.2	14.3	+.7	1:1
May 11	Clover	A	16.7	12.0	−28.1	31:1
		B	23.9	19.3	−19.2	13:1
	Corn	A	18.9	11.6	−38.6	356:1
		B	28.0	24.8	−11.4	16:1
Average of both strains in first two dates of planting			16.8	13.3	−20.8	663:1
May 21	Clover	A	17.4	22.8	+31.0	45:1
		B	28.9	33.1	+14.5	4:1
	Corn	A	19.7	21.2	+7.6	2:1
		B	31.6	31.5	−.3	1:1
May 31	Clover	A	22.5	26.6	+18.2	5:1
		B	33.8	38.4	+13.6	3:1
	Corn	A	46.0	45.7	−.7	<1:1
		B	52.9	51.1	−3.4	2:1
Average of both strains in last two dates of planting			31.6	33.8	+7.0	35:1

[1] Averages of 8 replications.
[2] University of Illinois Station strain of yellow dent.
[3] Reid yellow dent.

Date of planting also is an important factor in influencing the response of corn to seed treatment, as reflected in the percentage of lodged plants. (Table 32.) In the corn from the first two plantings, those of May 1 and May 11, corn from treated seed lodged less than that from untreated seed, the average decrease for the two strains being 20.8 per cent, with odds of 663 to 1. But in the corn from the two later plantings, those of May 21 and May 31, corn from treated seed had a larger percentage of lodged plants, 7 per cent increase, with odds of 35 to 1.

Genetic factors probably are the most important single set of factors concerned in resistance of corn to lodging. However, under conditions in which disease infections that start during the seedling stage may be an influencing factor in lack of resistance to lodging, seed treatment may be effective in reducing lodging. A few instances have been observed in which the plots from treated seed have had only a very few leaning plants, and the plots from untreated seed have had from 30 to over 50 per cent of leaning plants. (Fig. 17.) Although such instances have been the exception rather than the rule, they are of considerable interest. Of the nine statistically significant decreases and increases in percentages of plants leaning 30° or more, seven are decreases and two are increases. Although seed treatment may neither decrease nor increase lodging sufficiently to influence yield, corn from treated seed grown on soils on which corn appeared only 50 per cent in rotation (Table 31) and planted during the first half of the normal corn-planting season for the upper Mississippi Valley (Table 32) does show a significantly less tendency to lodge than corn from untreated seed.

EFFECTS ON EAR ROTS

Ear rots constitute a very important economic loss throughout the Corn Belt. But inasmuch as the great majority of these rots result from local infections during the period of maturation and not from infections in the seedling stage, seed treatment can not be expected to reduce this loss materially.

Data on the percentage of rotted ears in the crop grown from nearly disease-free seed and from different lots of diseased seed are presented

FIGURE 17.—Comparison of corn grown from untreated and treated seed with respect to lodging. Such a difference is the exception rather than the rule

in Table 33. The slight decreases in the proportion of rotted ears in series 1 from treated nearly disease-free seed and from treated seed primarily infected with Diplodia, Gibberella, and *Fusarium* spp., are not statistically significant. Nor is the small increase of 2.9 per cent of rotted ears from treated Basisporium-infected seed statistically significant. In series 2 (Table 33) there was a decrease of 8.2 per cent in the proportion of rotted corn, with odds of 22 to 1, in the corn grown from treated nearly disease-free seed and a decrease of 3.5 per cent, with odds of 28 to 1, in the corn grown from scutellum-rot susceptible seed. The decrease in the percentage of rotted ears in average farmers' seed, 6.6 to 5.9 per cent (Table 33) is statistically significant.

TABLE 33.—*Rotted ears in crop of yellow dent corn grown from nearly disease-free seed and from diseased seed, each untreated and treated, central Illinois, 1927–1929*

Series of experiments	Kind of seed	Experiments	Rotted ears in corn from seed—		Increase (+) or decrease (−) in rotted ears following seed treatment	Odds
			Untreated	Treated		
		Number	*Per cent*	*Per cent*	*Per cent*	
1	Nearly disease-free	13	6.8	6.3	−7.4	8:1
	Diplodia- and Gibberella-infected	16	7.8	7.5	−3.8	7:1
	Fusarium-infected	7	8.2	7.2	−12.2	9:1
	Basisporium-infected	7	7.0	7.2	+2.9	3:1
2	Nearly disease-free	15	7.3	6.7	−8.2	22:1
	Scutellum-rot susceptible	15	11.5	11.1	−3.5	28:1
3	Nearly disease-free	16	5.9	5.7	−3.4	4:1
	Diseased	16	5.8	5.5	−5.2	8:1
	Average farmers' corn	8	6.6	5.9	−10.6	152:1
	Average	113	7.4	7.0	−5.4	255:1

The data seem to suggest that seed treatment may have a slightly beneficial effect in reducing the percentage of ear rots. Averaging the data presented in Table 33, representing results from a total of 113 experiments over a 3-year period, the percentage of rotted ears was reduced from 7.4 per cent in the corn from untreated seed to 7.0 per cent in the corn from treated seed, a decrease of 5.4 per cent, with odds of 255 to 1. This slight reduction may be due in part to a possible reduction in source of inoculum by the reduction in blighted seedlings. This slight beneficial effect, however, probably can be attributed more largely to the increase in vigor of the plants from treated seed. The increased vigor enables the plants to flower slightly earlier and also to mature slightly earlier. Under some conditions the difference of only a very few days, even two or three, in the maturity of the crop may mean the difference between normal maturity and immaturity. Such a situation prevailed in the experiment the results from which are given in Table 34. Although the plots from untreated and from treated seed were about equal in total yield, the corn from the treated seed was significantly better matured, 9.5 per cent, with odds of 104 to 1. In an earlier planting or under different climatic conditions as the corn approached maturity the seed treatment might not have benefited the maturity of the crop to the same degree.

Other conditions being equal, normally matured corn has less ear rot than has corn not normally matured. Slight differences in maturity may have had a bearing on the results in Table 34, discussed in the above paragraph, and in the differences in series 2 and 3 of Table 33.

TABLE 34.—*Percentage of matured, solid ears in yellow dent corn grown from slightly diseased seed, untreated and treated, planted near Bloomington, Ill., May 24 and harvested November 30, 1928* [1]

Total acre yield from seed—		Matured solid ears from seed—		Increase in matured corn from treated seed	
Untreated	Treated	Untreated	Treated		
Bushels	*Bushels*	*Per cent*	*Per cent*	*Per cent*	*Odds*
57.3	57.0	64.4	70.5	9.5	104:1

[1] Average of 14 replications.

EFFECTS ON ACRE YIELD

Increases in stand and in vegetative vigor following the use of seed treatment may or may not result in increases in yield of grain, depending on a number of other influencing factors, such as water supply and amount of available plant nutrients at the critical periods of growth. In the sections in which the experiments have been conducted, data from which are presented in this bulletin, the use of seed disinfectants has been followed by rather consistent increases in yield. The size of the increases has been dependent on several factors. Some of the factors which are known to influence the response in yield to seed treatment will be discussed in the following paragraphs. But much remains to be learned concerning the many

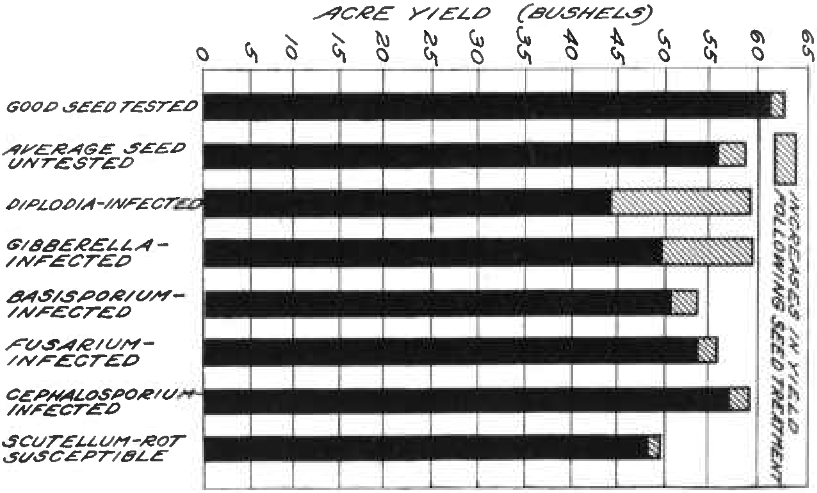


FIGURE 18.—Acre yields from various untreated and treated lots of seed. (Data from Table 35)

environmental factors which influence the response in yield to seed treatment.

FACTORS INFLUENCING AMOUNT OF INCREASE IN YIELD FROM SEED TREATMENT

SEED CONDITION

Data on the average increases in yield of corn from a number of seed lots differing in seed condition are given in Table 35 and are graphically presented in Figure 18. Averaging results from 96 experiments extending over a period of four years, the yield of corn from high-quality, well-selected, and tested seed was increased 1.5 bushels by seed treatment. Although this figure is small, it is statistically significant. The yield of corn from average seed that had not been tested was increased 3 bushels by seed treatment. This figure represents an average of 34 experiments and is statistically significant.

TABLE 35.—*Summarized data on acre yields of yellow dent corn from good seed tested, from average seed untested, from seed infected with Diplodia, Gibberella, Basisporium, Fusarium, and Cephalosporium, respectively, and from scutellum-rot susceptible seed, each untreated and treated, central Illinois, 1926–1929*

Kind of seed	Experiments	Acre yield from seed—		Increase in yield following seed treatment	Probable error of increase in yield	Increase / P. E.
		Untreated	Treated			
	Number	*Bushels*	*Bushels*	*Bushels*		
Good, tested	96	61.4	62.9	1.5	±0.2	7.5
Average, untested	34	55.9	58.9	3.0	±.3	10.0
Diplodia-infected	53	44.0	59.1	15.1	±.5	30.2
Gibberella-infected	31	49.7	59.5	9.8	±.7	14.0
Basisporium-infected	27	51.2	53.7	2.5	±.4	6.3
Fusarium-infected	12	53.7	55.7	2.0	±.5	4.0
Cephalosporium-infected	12	56.8	58.4	1.6	±.3	5.3
Scutellum-rot susceptible	11	48.9	49.3	.4	±.3	1.3

The largest increases in yield following seed treatment came from seed naturally infected with Diplodia and Gibberella, the increases being 15.1 and 9.8 bushels, respectively. The acre yields of corn grown from treated Diplodia-infected and Gibberella-infected seed, 59.1 and 59.5 bushels, respectively, compare favorably with the average yield of corn from treated average seed, 58.9 bushels. These data indicate that the Diplodia and Gibberella infections that occur in well-selected seed can be controlled satisfactorily by the use of the better seed-corn disinfectants.

The yield of corn from Basisporium-infected seed was increased only 2.5 bushels by seed treatment, but this is a statistically significant figure. The yield of corn from treated Basisporium-infected seed was lower than that from treated Gibberella-infected seed, 55.7 bushels as compared with 59.5 bushels.

The yields of corn from Fusarium-infected seed and from Cephalosporium-infected seed were increased 2.0 and 1.6 bushels, respectively, by seed treatment. Corn from scutellum-rot susceptible seed was not materially benefited by the use of seed treatment.

In some strains of corn the crop grown from scutellum-rot susceptible seed, as well as that from seed slightly infected with Basisporium, may respond to seed treatment in increased production, producing yields almost equal to those from the best-quality seed of the same strains.

VARIETAL RESPONSE

Strains of corn differ widely in their yield responses to the use of seed treatment, the seed condition and other influencing factors being comparable. Data showing varietal or strain difference in response to seed treatment are given in Table 36. The yields of the strain designated as C were increased 1.4, 1.1, and 3.8 bushels in each of three experiments. In these same three experiments the yields of the strain designated as D were increased 5.0, 4.0, and 7.2 bushels by the use of the same seed disinfectant. Averaging the three experiments, the yield of strain C was increased 2.1 bushels and the yield of strain D 5.4 bushels.

Occasionally varieties and strains have been used the yield of which was not improved by the use of any seed disinfectant. The yield of strain H (Table 36) was not increased by the use of seed treatment, although the yield of strain D in the same series of experimental plots was increased 7.2 bushels, with high odds, by the use of the same seed disinfectant.

TABLE 36.—*Comparison of responses to seed treatment with class A seed disinfectants of different strains of yellow dent corn, seed of equally good quality being used in each comparison, central Illinois, 1927 and 1928*

Series	Designation of strain of corn	Acre yield from seed— Untreated	Acre yield from seed— Treated	Increase following seed treatment	Odds
		Bushels	*Bushels*	*Bushels*	
1	A	39.2	40.0	0.8	2:1
	B	39.6	47.3	7.7	2,499:1
2	C	66.6	68.0	1.4	5:1
	D	68.1	73.1	5.0	114:1
3	E	76.7	77.3	.6	1:1
	F	65.0	70.4	5.4	91:1
4	C	55.2	56.3	1.1	4:1
	D	56.5	60.5	4.0	31:1
5	C	69.4	73.2	3.8	1,821:1
	D	66.6	73.8	7.2	>9,999:1
	H	55.4	55.6	.2	1:1
Average of C strain		63.7	65.8	2.1	14:1
Average of D strain		63.7	69.1	5.4	67:1

SOIL COMPLEX

Although condition of seed and individuality of variety or strain are very important factors in influencing the amount of increase in yield following seed treatment, the soil complex on which the crop is grown is equally important. In general, other known factors being equal, the yield of corn from good seed, grown on soil higher in organic matter and more productive, usually is increased more by the use of seed treatment than is the yield of corn from the same lot of well-selected seed grown on comparable soil lower in organic matter and in productivity. Averaging the results from five field experiments in which such a comparison could be made, the average increase in yield on the less productive soil was 1.2 bushels, with odds of 49 to 1, and the average increase on the more productive soil was 5.2 bushels, with odds of 561 to 1. (Table 37.)

TABLE 37.—*Comparison of responses to seed treatment with class A disinfectants of the same strain of yellow dent corn on two experimental plots in each of five localities, one of the two experimental plots in each comparison being located on soil higher in organic matter and productivity than the other; central Illinois, 1927 and 1928*

Series	Levels of productivity	Acre yield from seed— Untreated	Acre yield from seed— Treated	Increase in yield following seed treatment	Odds
		Bushels	*Bushels*	*Bushels*	*Odds*
1	Lower	47.0	47.4	0.4	3:1
	Higher	54.6	59.2	4.6	130:1
2	Lower	76.8	78.1	1.3	3:1
	Higher	83.6	86.5	2.9	78:1
3	Lower	40.4	43.0	2.6	12:1
	Higher	71.2	78.4	7.2	695:1
4	Lower	58.4	59.8	1.4	42:1
	Higher	66.6	73.8	7.2	>9,999:1
5	Lower	60.6	60.9	.3	1:1
	Higher	75.7	79.7	4.0	92:1
Average of lower		56.6	57.8	1.2	49:1
Average of higher		70.3	75.5	5.2	561:1

The interrelation of seed condition and the soil complex in influencing the amount of increase in yield following seed treatment is shown by the data in Table 38. With corn from good seed, the increases in yield following seed treatment were greater where corn followed a legume in the rotation than where corn followed corn. In the rotation corn, corn, spring grains, and clover, the increase in yield following seed treatment on the plots whose previous crop had been clover was 3 bushels, with odds of 832 to 1, as compared with a slight decrease on the plots of the same rotation where corn followed corn. Likewise, in the rotation corn, corn, corn, and soybeans, the increase in yield following seed treatment was 2.0 bushels, with odds of 734 to 1, on the plots whose previous crop had been soybeans, and only 1.5 bushels, with odds of 13 to 1, where corn followed corn.

TABLE 38.—*Acre yields of yellow dent corn from untreated and treated good and diseased seed, planted early in May on two rotations, University of Illinois agronomy farm, Urbana, Ill., 1929*

Seed condition and rotation	Previous crop or crops	Replications	Acre yield from seed— Untreated	Acre yield from seed— Treated	Increase (+) or decrease (−) in acre yield following seed treatment		Odds
		Number	*Bushels*	*Bushels*	*Bushels*	*Per cent*	
Good seed:							
Corn, corn, spring grains, clover	Clover	16	64.1	67.1	+3.0	+4.7	832:1
	Corn	16	59.7	58.6	−1.1	−1.8	4:1
Corn, corn, corn, soybeans	Soybeans	16	44.4	46.4	+2.0	+4.5	734:1
	Two years of corn	16	36.1	37.6	+1.5	+4.2	13:1
Diseased seed:							
Corn, corn, spring grains, clover	Clover	16	48.7	55.2	+6.5	+13.3	96:1
	Corn	8	32.2	47.3	+15.1	+46.9	4,332:1
Corn, corn, corn, soybeans	Soybeans	16	39.9	41.1	+1.2	+3.0	2:1
	Two years of corn	16	28.7	32.4	+3.7	+12.9	53:1

With corn from diseased seed the situation was reversed. The increase in yield of corn from diseased seed, following seed treatment, was 15.1 bushels, or 46.9 per cent, with odds of 4,332 to 1, on the plots where the previous crop was corn, as compared with an increase of 6.5 bushels, or 13.3 per cent, with odds of 96 to 1, where corn followed clover. (Table 38.) In the other rotation the increase in yield following seed treatment also was greater where corn followed corn than where corn followed soybeans, 3.7 bushels, with odds of 53 to 1, as compared with 1.2 bushels, with odds of 2 to 1.

Additional data on the importance of previous cropping as a factor in influencing the amount of the increase in yield following seed treatment are given in Table 39. Although no increases in yield could be attributed to seed treatment in any of the plots following a legume crop, there were substantial increases in yield due to seed treatment where corn followed corn in the rotation.

TABLE 39.—*Acre yields* [1] *of yellow dent corn from untreated and treated seed of a first-generation cross, F_1–250, the seed of which showed different degrees of Basisporium infection; corn grown on plots following a legume and on plots following corn, planted May 4, 1929, at the University of Illinois agronomy farm, Urbana, Ill.*

Description of seed lots, a part of each lot coming from each of 50 ears	Previous crop	Acre yield from seed— Untreated	Acre yield from seed— Treated	Increase (+) or decrease (−) in yield following seed treatment		Odds
		Bushels	*Bushels*	*Bushels*	*Per cent*	
Lot 1: Basisporium spore masses on kernels easily visible to the naked eye	Legumes	46.1	48.1	+2.0	+4.3	15:1
	Corn	28.4	37.4	+9.0	+31.7	50:1
Lot 2: Basisporium spore masses on kernels visible only with magnifying glass	Legumes	44.5	45.4	+.9	+2.0	3:1
	Corn	32.6	37.2	+4.6	+14.1	20:1
Lot 3: No Basisporium spore masses on kernels	Legumes	47.1	47.9	+.8	+1.7	2:1
	Corn	30.6	36.6	+6.0	+19.6	46:1

[1] Averages of 6 and 8 replications.

TIME OF PLANTING

Experiments were conducted during 1927, 1928, and 1929 in planting good seed, untreated and treated, at four successive dates in May at intervals of approximately 10 days. Data from these experiments are presented in Table 40. Under the conditions represented in these experiments the only increase in yield occurred in the first planting, 1.4 bushels, with odds of 494 to 1. In other experiments, however, very substantial increases in yield following treatment of good seed have come from plantings near the middle of May that were followed by a period of warm, rainy weather.

TABLE 40.—*Acre yields* [1] *of yellow dent corn from good seed planted at four dates, seed untreated and seed treated, University of Illinois agronomy farm, Urbana, Ill., 1927–1929*

Date of planting	Acre yield from untreated seed	Increase (+) or decrease (−) in yield following seed treatment	Odds
	Bushels	*Bushels*	
May 1 or 2	50.1	+1.4	494:1
May 11 or 12	48.9	+.4	6:1
May 21	47.1	−.5	6:1
May 31	40.6	−.1	1:1

[1] Averages of 12 experiments for each date of planting.

COMPARISON OF COMMERCIALLY AVAILABLE DUSTS

Data on the corn-seed disinfectants commercially available at the time the experiments herein reported were conducted are presented in Table 41 and summarized in Table 42.

TABLE 41.—*Acre yield of yellow dent corn from variously infected and average seed, untreated and treated with certain commercial organic mercury disinfectants, in experiments at various points in central Illinois, 1926–1929*

Year and location of experiment	Designation of experiment	Kind of seed	Replications	Acre yield of sound corn from untreated seed and increase or decrease in yield following seed treatment with—														
				Hydroxymercurinitrophenol (Bayer Dust)			Cyanmercuricresol (S. F. A. 225)			Hydroxymercuricresol (improved Semesan Jr.)			Merko			Mercury furfuramide (Sterocide)		
				Acre yield of sound corn from untreated seed	Increase (+) or decrease (−) following seed treatment	Odds	Acre yield of sound corn from untreated seed	Increase (+) or decrease (−) following seed treatment	Odds	Acre yield of sound corn from untreated seed	Increase (+) or decrease (−) following seed treatment	Odds	Acre yield of sound corn from untreated seed	Increase (+) or decrease (−) following seed treatment	Odds	Acre yield of sound corn from untreated seed	Increase (+) or decrease (−) following seed treatment	Odds
1926			*No.*	*Bushels*	*Bushels*		*Bushels*	*Bushels*		*Bushels*	*Bushels*		*Bushels*	*Bushels*		*Bushels*	*Bushels*	
Bloomington	A	Nearly disease-free	8	60.7	−0.5	3:1	60.5	+0.8	4:1	60.9	+2.6	41:1	---	---	---	---	---	---
		Diplodia-infected	8	45.5	+9.9	1,999:1	45.8	+10.5	527:1	46.7	+9.6	>9,999:1	---	---	---	---	---	---
		Gibberella-infected	8	42.4	+.3	1:1	42.4	+4.9	69:1	---	---	---	---	---	---	---	---	---
Bondville	B	Nearly disease-free	8	37.4	−.5	2:1	39.2	+.8	2:1	37.5	−.5	2:1	---	---	---	---	---	---
		Diplodia-infected	8	29.1	+8.1	408:1	33.1	+9.2	2,399:1	33.4	+5.5	81:1	---	---	---	---	---	---
		Scutellum-rot susceptible	8	38.7	−1.5	5:1	39.9	−.1	1:1	38.5	−2.0	3:1	---	---	---	---	---	---
1927																		
Bloomington	C	Nearly disease-free	8	56.2	−2.7	12:1	54.5	+1.1	2:1	54.1	+3.4	31:1	---	---	---	---	---	---
		Diplodia-infected	8	32.0	+15.9	506:1	32.7	+22.5	>9,999:1	33.3	+16.9	525:1	---	---	---	---	---	---
		Gibberella-infected	8	39.2	+14.7	270:1	37.4	+16.7	>9,999:1	37.2	+19.1	4,999:1	---	---	---	---	---	---
		Basisporium-infected	8	39.0	+5.2	11:1	44.9	−.7	1:1	42.4	+1.4	5:1	---	---	---	---	---	---
		Fusarium-infected	8	49.4	+5.6	132:1	48.2	+5.2	29:1	46.3	+4.9	26:1	---	---	---	---	---	---
		Cephalosporium-infected	8	51.1	+0	---	51.7	+2.4	92:1	50.8	+1.2	4:1	---	---	---	---	---	---
Do	D	Nearly disease-free	8	46.3	+2.1	7:1	50.1	+.2	1:1	49.2	+.3	1:1	---	---	---	---	---	---
		Diseased	4	38.5	−.7	4:1	36.3	+9.7	740:1	39.4	+8.6	112:1	---	---	---	---	---	---
Do	E	Nearly disease-free	4	61.9	−2.0	1:1	60.6	+1.6	10:1	60.2	+0	---	---	---	---	---	---	---
		Diplodia-infected	4	41.9	+12.3	175:1	37.2	+21.2	2,499:1	39.7	+13.0	87:1	---	---	---	---	---	---
		Basisporium-infected	4	55.8	+1.4	2:1	55.4	+5.7	12:1	54.9	+3.8	4:1	---	---	---	---	---	---

TABLE 41.—*Acre yield of yellow dent corn from variously infected and average seed, untreated and treated with certain commercial organic mercury disinfectants, in experiments at various points in central Illinois, 1926–1929*—Continued

Year and location of experiment	Designation of experiment	Kind of seed	Replications	Acre yield of sound corn from untreated seed and increase or decrease in yield following seed treatment with—														
				Hydroxymercurinitrophenol (Bayer Dust)			Cyanmercuricresol (S. F. A. 225)			Hydroxymercuricresol (improved Semesan Jr.)			Merko			Mercury furfuramide (Sterocide)		
				Acre yield of sound corn from untreated seed	Increase (+) or decrease (−) following seed treatment	Odds	Acre yield of sound corn from untreated seed	Increase (+) or decrease (−) following seed treatment	Odds	Acre yield of sound corn from untreated seed	Increase (+) or decrease (−) following seed treatment	Odds	Acre yield of sound corn from untreated seed	Increase (+) or decrease (−) following seed treatment	Odds	Acre yield of sound corn from untreated seed	Increase (+) or decrease (−) following seed treatment	Odds
1927			*No.*	*Bushels*	*Bushels*		*Bushels*	*Bushels*		*Bushels*	*Bushels*		*Bushels*	*Bushels*		*Bushels*	*Bushels*	
Urbana	F	Nearly disease-free	8	54.6	+4.6	130:1	58.8	+.5	2:1	60.1	+.1	1:1						
		Diplodia-infected	8	43.8	+10.0	113:1	43.6	+13.1	69:1	43.6	+17.5	322:1						
		Gibberella-infected	8	53.3	+6.9	50:1	49.9	+6.2	37:1	51.4	+8.8	28:1						
		Basisporium-infected	8	52.2	+3.0	22:1	54.4	−.2	1:1	51.4	+2.2	3:1						
		Fusarium-infected	8	55.8	+1.9	17:1	56.2	+1.9	7:1	56.0	−.7	3:1						
		Cephalosporium-infected	8	56.6	+.4	2:1	56.7	+2.7	14:1	58.0	+1.8	15:1						
		Scutellum-rot susceptible	8	55.5	+2.4	11:1	57.2	+.5	2:1	57.4	+2.0	16:1						
Do	G	Nearly disease-free	8	77.4	−.8	1:1	76.6	+1.0	2:1	78.5	+0							
		Diplodia-infected	8	52.4	+20.7	4,999:1	51.0	+29.6	>9,999:1	49.1	+30.3	>9,999:1						
Hillsdale	H	Nearly disease-free	6	101.6	+3.4	5:1				99.4	+6.3	60:1						
		Diplodia-infected	6	79.0	+15.2	567:1				77.9	+24.7	>9,999:1						
Lincoln	I	Nearly disease-free	7	67.2	−.1	1:1				66.2	+1.9	7:1						
		do	7	71.6	−.1	1:1				67.8	+2.1	5:1						
		Gibberella-infected	6	63.4	+3.1	3:1	63.4	+7.3	35:1	57.0	+15.5	603:1						
Do	J	Nearly disease-free	6	68.5	+3.5	5:1	68.5	+6.7	30:1	68.5	+4.9	16:1						
		Diplodia-infected	6	56.4	+11.9	232:1	54.7	+15.1	121:1	54.7	+16.7	189:1						
McNabb	K	Nearly disease-free	8	56.4	+1.0	1:1	54.5	+1.5	3:1	56.2	+1.8	31:1						
		do	8	62.9	+2.0	3:1	63.5	−.9	2:1	62.5	+1.9	4:1						
		Diplodia-infected	4	43.4	+15.7	964:1	41.5	+9.8	63:1	41.5	+15.3	792:1						
		Gibberella-infected	6	52.4	+4.6	26:1	53.9	+3.2	9:1	54.0	+4.4	19:1						
		Basisporium-infected	4	46.6	+4.3	94:1	46.7	+3.2	26:1	46.7	+3.7	281:1						

Bloomington	L	Average seed, untested	8	50.0	+1.1	2:1	50.2	+1.9	3:1	49.9	+7.2	4,999:1						
		do	8	40.6	+3.4	8:1	42.6	+3.9	14:1	42.2	+8.4	1,523:1						
Urbana	M	do	10	67.9	+2.2	23:1	68.3	+.7	4:1	65.3	+.8	6:1						
1928																		
Bloomington	N	Nearly disease-free	12	67.2	−.4	1:1	69.4	+1.2	7:1	69.8	+2.3	16:1						
		Diplodia-infected	12	46.1	+16.5	>9,999:1				42.5	+13.9	>9,999:1						
		Gibberella-infected	12	48.2	+12.1	>9,999:1				52.0	+16.9	>9,999:1						
Do	O	Nearly disease-free	10							66.6	+7.2	>9,999:1	65.8	−.8	2:1			
		Diplodia-infected	10							46.4	+12.8	>9,999:1	47.2	+11.8	>9,999:1			
Urbana	P	Nearly disease-free	8				54.8	+1.7	8:1	53.7	+2.1	132:1	50.1	+4.2	>9,999:1			
		Diplodia-infected	8				38.7	+12.8	>9,999:1	39.3	+7.9	1,066:1	34.8	+12.3	>9,999:1			
		Gibberella-infected	8				43.7	+8.6	737:1	45.1	+9.7	1,766:1	41.7	+8.8	>9,999:1			
		Basisporium-infected	8				51.9	+1.2	7:1	52.2	+1.5	11:1	49.5	+.7	5:1			
		Fusarium-infected	8				51.3	+.7	8:1	52.2	+0		48.1	+.9	7:1			
		Cephalosporium-infected	8				52.9	+0		50.0	+3.5	22:1	46.4	+4.2	37:1			
		Scutellum-rot susceptible	8				53.2	+.8	7:1	53.7	+.4	2:1	51.6	+1.2	10:1			
Do	Q	Nearly disease-free	8							49.3	+.8	5:1	50.7	+.7	5:1			
		do	8							47.6	+1.7	38:1	48.3	+1.8	31:1			
		do	8							43.1	+.3	2:1	44.6					
		do	8							38.8	+.4	3:1	38.9	+1.6	21:1			
Do	R	Average seed, untested	8							48.1	+2.1	22:1	49.2	+1.3	27:1			
		do	8							43.3	+1.7	68:1	44.8	+1.5	27:1			
		do	8							35.5	+.3	2:1	34.9	+1.5	19:1			
		do	8							28.5	+1.3	20:1	27.3	+2.4	122:1			
Do	S	Average farmers' seed	10	50.1	+2.2	100:1				52.4	+2.9	>9,999:1	52.1	+2.4	23:1			
Bloomington	T	Average seed, untested	10							63.2	+3.2	28:1	64.2	+.6	2:1			
1929																		
Bloomington	U	Good seed, untested	18							52.3	+8.0	>9,999:1	52.3	+7.2	1,666:1	50.5	+7.5	1,110:1
		Nearly disease-free	20							56.8	+4.9	99:1	56.8	+4.0	12:1	59.9	+1.3	3:1
		Diplodia-infected	20							23.4	+28.2	>9,999:1	23.4	+19.2	82:1	29.2	+18.3	>9,999:1
		Gibberella-infected	16							46.1	+6.0	105:1	46.1	+8.6	>9,999:1	45.5	+6.8	277:1
		Basisporium-infected	16							53.6	+1.1	3:1	53.6	−1.4	4:1	53.6	+2.0	3:1
		Scutellum-rot susceptible	20							49.5	+9.8	>9,999:1	49.5	+3.6	16:1	49.8	+2.4	10:1
Urbana	V	Nearly disease-free	8							51.3	+2.1	40:1	53.5	+.9	7:1			
		do	8							51.8	−1.3	4:1	51.0	−1.3	3:1			
Do	W	Average seed	8							50.6	+3.5	50:1	51.6	+4.2	71:1			
		do	8							48.6	+2.0	42:1	50.4	+.7	3:1			
Do	X	Average farmers' seed	10							68.9	+3.0	27:1	69.1	+.6	2:1	68.9	+1.8	12:1

TABLE 42.—*Summarized data from Table 41 showing mean increases in yield from various seed selections treated with certain commercial organic mercury disinfectants, 1926–1929*

Year and kind of seed	Increase in acre yield following seed treatment with—				
	Bayer dust	S. F. A. 225	Improved Semesan Jr.	Merko	Sterocide
1926–27	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*
Diplodia-infected	13.3	16.4	16.6		
Gibberella-infected	5.9	7.7	12.0		
Basisporium-infected	3.5	2.0	2.8		
Fusarium-infected	3.8	3.6	2.1		
Cephalosporium-infected	.2	2.6	1.5		
Scutellum-rot susceptible	.5	.2	0		
Diseased seed lots averaged	4.5	5.4	5.8		
Average seed, untested	2.2	2.2	5.5		
Nearly disease-free	.7	1.6	1.9		
1928					
Diplodia-infected	16.5	12.8	11.5	12.1	
Gibberella-infected	12.1	8.6	13.3	8.8	
Basisporium-infected		1.2	1.5	.7	
Fusarium-infected		.7		.9	
Cephalosporium-infected			3.5	4.2	
Scutellum-rot susceptible		.8	.4	1.2	
Diseased seed lots averaged		4.0	6.0	4.7	
Average seed, untested			1.7	1.5	
Average farmers' seed	2.2		2.9	2.4	
Nearly disease-free	[1] −.4	1.5	3.1	1.4	
1929					
Diplodia-infected			28.2	19.2	18.3
Gibberella-infected			6.0	8.6	6.8
Basisporium-infected			1.1	[1] −1.4	2.0
Scutellum-rot susceptible			9.8	3.6	2.4
Diseased seed lots averaged			11.3	7.5	7.4
Average farmers' seed			3.0	.6	1.8
Average seed			2.8	2.5	
Good seed, untested			8.0	7.2	7.5
Nearly disease-free			1.9	1.2	1.3

[1] Decreases in yield following seed treatment.

EFFECT OF SEED TREATMENT ON RATE OF DROP FROM CORN PLANTER

Koehler and Shawl (*9*) reported that treated seed dropped somewhat more irregularly than untreated seed, the accuracy of drop being decreased 5 per cent. The total corn dropped in a given time, however, was not affected appreciably. In other studies conducted by the senior writer of this bulletin it was found that the variety of corn and the selection of planter plates for the particular type and size of kernels concerned were important factors in determining the extent to which seed treatment influenced rate and accuracy of drop. With well-graded seed corn and proper-sized planter plates, it was found possible to secure a satisfactory rate of drop with seed treated with dust disinfectants, data on which are given in Tables 41 and 42.

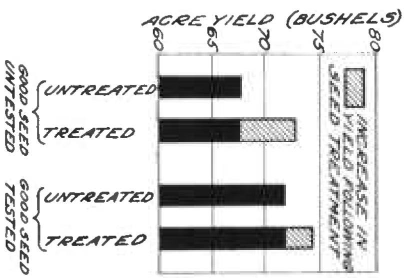


FIGURE 19.—Average acre yields from good seed, untested and tested, and untreated and treated. (Data from Table 43)

POSSIBLE PLACE OF SEED TREATMENT IN CORN PRODUCTION AND IMPROVEMENT

Data on the value of seed treatment on well-selected lots of seed corn, untested and tested, are given in Table 43, summarized in Table 44, and presented graphically in Figure 19. Averaging the results from the 11 experiments, the use of seed treatment increased the acre yield of good untested seed 4.9 bushels, with odds of 9,999 to 1, and good tested seed 2.4 bushels, with odds of 399 to 1. (Table 43.) Under the conditions represented by these experiments, seed treatment was equally as effective as the germination test in increasing yields, 72.8 bushels as compared with 71.8 bushels.

Consistent increases in yield have been secured from the use of seed treatments on well-selected lots of seed capable of producing satisfactory yields. The yield of average farmers' seed was increased about 3 bushels by seed treatment. (Table 42.)

Such data would seem to indicate that the use of seed treatment is not incompatible with corn-breeding and corn-improvement programs.

TABLE 43.—*Acre yield of corn grown from well-selected but untested seed, from well-selected seed testing nearly disease-free on the germinator, and from seed untreated and seed treated with hydroxymercuricresol (improved Semesan Jr.), in central Illinois, 1927–1929*

Location of experiment and year	Variety and kind of seed	Replications	Acre yield from seed—		Increase in yield following seed treatment	
			Untreated	Treated		
		Number	*Bushels*	*Bushels*	*Bushels*	*Odds*
Bloomington (1927)	Funk 90-Day:					
	Good, untested	8	42.2	50.6	8.4	1,523:1
	Good, tested	8	49.2	49.5	.3	1:1
Do	Funk 176-A:					
	Good, untested	8	49.9	57.1	7.2	4,999:1
	Good, tested	8	54.1	57.5	3.4	31:1
Bloomington (1928)	University of Illinois Yellow Dent:					
	Good, untested	20	81.6	81.8	.2	1:1
	Good, tested	20	81.0	82.2	1.2	4:1
Granville (1928)	University of Illinois Yellow Dent:					
	Good, untested	6	69.0	76.8	7.8	60:1
	Good, tested	6	72.9	74.7	1.8	2:1
Bloomington (1928)	Funk 176-A:					
	Good, untested	20	64.7	68.4	3.7	434:1
	Good, tested	20	69.4	73.2	3.8	1,821:1
Galesburg (1928) [1]	Yellow dent (McBride strain):					
	Good, untested	12	75.4	75.9	.5	1:1
	Good, tested	12	77.4	77.6	.2	1:1
Galesburg (1928) [2]	Yellow dent (McBride strain):					
	Good, untested	12	85.3	89.9	4.6	89:1
	Good, tested	12	84.9	85.3	.4	2:1
Hillsdale (1928)	F_1-250:					
	Good, untested	12	98.6	104.2	5.6	179:1
	Good, tested	12	109.0	110.6	1.6	5:1
Bloomington (1928) [3]	Yellow dent:					
	Good, untested	20	64.8	69.2	4.4	>9,999:1
	Good, tested	20	68.4	69.8	1.4	42:1
Bloomington (1928) [4]	Yellow dent:					
	Good, untested	10	63.2	66.6	3.4	28:1
	Good, tested	10	66.6	73.8	7.2	>9,999:1
Bloomington (1929)	Hybrid 517:					
	Good, untested	16	52.3	60.3	8.0	>9,999:1
	Good, tested	16	56.8	61.7	4.9	99:1
Average	Good, untested		67.9	72.8	4.9	>9,999:1
	Good, tested		71.8	74.2	2.4	399:1

[1] Experimental plots on soil that had received no special soil treatment.
[2] Experimental plots on soil that had received manure, rock phosphate, and limestone.
[3] Early planting.
[4] Later planting on more productive soil.

TABLE 44.—*Summarized data from Table 43 on the value of seed treatment with Semesan Jr., on well-selected seed, untested and tested, central Illinois, 1927–1929*

Description of seed	Acre yield	Increase in acre yield over good seed, untested and untreated	
	Bushels	*Bushels*	*Odds*
Good seed, untested and untreated	67.9		
Good seed, tested and untreated	71.8	3.9	1,099:1
Good seed, untested and treated	72.8	4.9	>9,999:1
Good seed, tested and treated	74.2	6.3	3,665:1

SUMMARY

Investigations on the value of corn-seed disinfectants have been conducted over a period of 11 years.

At the beginning of this period liquid treatments were more effective than the dust disinfectants that were then available. At the present time dust disinfectants have entirely replaced the liquid treatments.

Suitable corn-seed dust disinfectants are effective in controlling such infections of Diplodia and Gibberella as occur in well-selected lots of seed. These dust disinfectants also aid in controlling other seed-borne diseases and offer some protection against soil-borne diseases.

The use of seed treatments is usually followed by better stands and increased early vegetative growth. Occasionally corn grown from treated seed has had somewhat greater resistance to lodging. Ear rots were slightly reduced by the use of seed treatments. The yield of corn grown from average farmer's seed was increased about 3 bushels by the use of the better corn-seed dust disinfectants.

With well-selected lots of seed under proper storage conditions, seed treatment was found to be as effective as the germination test in increasing yields.

It appears that seed treatment may be considered and used as an effective means of guarding against such losses as result from seed-borne infections and soil-borne diseases that adversely affect corn plants during the young-plant stage.

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